Popular Astronomy.

Vol. III. No. 9. MAY, 1896. Whole No. 29.

CHRONOLOGICAL NOTES.—I.

R. W. McFARLAND.

FOR POPULAR ASTRONOMY.

THE CALENDAR.—It is here proposed to set forth more or less fully several points in our general calendar;—points which may not be familiar to all the readers of this Journal. Preceding articles have explained some facts relating to the common almanac. These will be devoted to cognate topics, and all are included under the general title at the head of this article.

From time "to which the memory of man runneth not to the contrary," English speaking youth have been troubled with the lines

"Thirty days hath September,
April, June, and November," etc., etc.

Here is a brief sketch of the way in which this "unhappy" arrangement grew up. It has been an example of "evolution" greatly vexed, at times, by the environment.

As mentioned in a previous article, we use substantially the Roman calendar, as do all the nations of Europe. When did it originate? Nobody knows. We know only that the division of the year into ten months is attributed to Romulus, the reputed founder of Rome, about seven and a half centuries before Christ. But the researches of modern scholars have shown that the stories about Romulus are chiefly, if not wholly, myths; and that for two or three hundred years or more, subsequent to the founding of Rome, the so-called history is greatly of the complexion of the older stories. [See Niebuhr and others.]

Nevertheless, without giving credence to these old stories, we may be satisfied that in the early days of Rome the year had only ten months; and for all there is in it, Romulus may as well be considered the originator of the fact, as any one else. The names were as follows: Martius, Aprilis, Maius, Junius, Quintilis, Sextilis, September, October, November, December.

These words are all adjectives, and the word *mensis* (month) was sometimes expressed, but more frequently was understood; the last four were frequently used as nouns, as they are now, meaning, as the slightest knowledge of Latin will show, the

seventh, eighth, ninth, and tenth month, respectively. But as now used they denote the ninth, tenth, eleventh, and twelfth. Numa, the reputed successor of Romulus, is credited with the addition of the two months February and January, in this order, at the end of the year, March being the first month.

About the middle of the fifth century before Christ—it is usually given as 452—the ruling authority in Rome at that time—the Decemvirs—changed the order of the two new months, putting January before February, thus making February the last month of the year. Whatever may have been the number of days given to the several months antecedent to the above date, afterwards the months contained 29 and 30 days alternately, corresponding to the motions of the Moon, which completes a synodic revolution in 29½ days very nearly. [More exactly, 29^{d}, 12^{h} 44^{m} 2.8^{s}, Herschel]. Twelve of these revolutions make a few hours over 354 days, wanting about 11 days of being a full solar year. But it is said that because "odd" numbers were considered "lucky," these magistrates made the year 355 days, while they still used the 11 as the number of days to make the lunar year agree with the solar. Wherefore it was ordered that at the end of two years, an intercalary month of 22 days should be inserted near the end of February—between the 23d and 24th; and at the end of the next two years, a month of 23 days should be similarly inserted, and so on alternately. This, of course, is only a very rough approximation to the real motions of the Sun and Moon. I am merely giving the history of the case,—not reconciling discrepancies.

The pontiffs of Rome had a certain discretion, or they took liberties, concerning the application of the above orders, so that in time the year's length became irregular, and the months began on such days as they ordered without regard to the place of the Sun or the Moon.

In truth, long before the time of Julius Caesar, it became a mere question of *politics*—which always, in ancient or in modern times, seems to defile and to debase all who devote their lives to it. So much had this interference disturbed the reckoning, that the year before the Julian reformation consisted of 445 days. This year very naturally acquired the name of "the last year of confusion."

Caesar's ability as a ruler of men and of things is further exemplified by the fact that in his proposed reformation of the calendar, he called Sosigenes, a competent astronomer of Alexandria, Egypt, to render assistance. The result was that the lunar year was entirely discarded, and the Sun was made the ruler of the calendar, as it is of the seasons.

It was ordered that the year should begin with January, instead of March, as it had begun before: that the standard year should consist of 366 days, having 12 months, six of which should contain 31 days, and the other six, 30 days: that the "odd" months, 1, 3, 5, 7, etc., should have the odd numbers of days, and the "even" months, 2, 4, 6, etc., should have 30 days: that the other three years of the four, should consist of 365 days each, by dropping the *last day of the year, Feb. 30*, thus leaving February with 29 days in ordinary years. This calendar of Caesar is the best one ever made, and it might have remained from that day to this but for the vanity of Augustus, who for a long time, was emperor of the Roman dominions. The calendar was conceived in the right spirit, and was adjusted without intercalary days, the shorter years merely dropping one day.

It has been a sort of universal custom with calendar makers, to make adjustments by adding intercalary days at or near the end of the year, as given above in reference to the Decemvirs. The new calendar of France promulgated in 1792, made the year consist of 12 months having 30 days each, and at the end a period of 5 intercalary days in common years, and 6 in leap years. This was only the old Egyptian calendar, known and used centuries before the time of Moses;—with this difference only, that all the years had 5 days added. In this way one day was lost in four years; so in the lapse of ages, the feasts of the gods would fall on every day of the year—all the gods being thus equally honored. That the year consisted of 365¼ days very nearly, was known from very remote times among the Egyptians. The period of 5 months of 30 days each mentioned in the 7th chapter of Genesis, and referred to in one of my previous articles, is only the old Egyptian calendar, well known to Moses, for he "was learned in all the wisdom of the Egyptians."

It may not be inappropriate to give the following extract from the article Julius Caesar, in Anthon's Classical Dictionary. "From his earliest boyhood Caesar discovered extraordinary talents. He had a penetrating intellect, a remarkably strong memory, and a lively imagination; was indefatigable in business and able, as we are told by Pliny, to read, write, hear, and dictate, at one and the same time, from four to seven different letters."

The reformation of the calendar, therefore, was in the line of Caesar's natural activity. It brought order out of confusion, and it would have remained a fitting monument, "more lasting than brass," but for his accomplished, though weaker successor, Augustus.

Caesar was assassinated on the Ides of March, a little over a year after the beginning of the Julian Calendar, which was January 1, 45 B. C. By his death, the strong arm which could have kept the helm steady, was lost; and those having charge of the calendar seem not to have mastered its provisions. Instead of counting leap year once in 4 years, they put it in every third year for 36 years; making thus 12 leap years instead of 9. This result came probably from the general Roman method of counting the days of month. Thus the Ides of March was the 15th; the day before was called *pridie Idus*, [the first day before the Ides]; the 13th was called the *third day before the Ides*, and to make *three* the Ides must be counted in as one of the three. In like manner every fourth year was to be a leap year. Supposing the first year of the new calendar to have been a leap year, [see extract from Herschel below], this first was called number one of the cycle of four years; 2, was the second; 3, the third; and 4, the fourth, so that the year 4 was the second leap year. By a like process, commencing with the fourth year, the next leap year would fall in the seventh year of the new calendar, and so on till the error was noticed by Augustus. He ordered that from the 37th to the 48th year inclusive of the new calendar, there should be no leap year. By the preceding way of counting, this 48th year was 4th of the Christian Era; so the modern chronologists usually name the year 8 as the first leap year of the Christian era. Other chronologists (among them Hutton), say that the year 7 of our era was the first leap year. This arises from counting the new calendar as beginning January 1st, 46 B. C. But the weight of authority is for 45. Hutton further says that there were no leap years between the years 459 and 474; and that the years before 459 which were leap years, were not those divisible by 4, but always one less than the numbers so divisible: and that after 474 to the reformation of the calendar by Gregory XIII, the leap years were those divisible by 4.

It is easily seen, therefore, that in the matter of dates there is supreme confusion,—there is no certainty at all. There is a difference of 7 years in the reputed founding of Rome. The pontiffs from 452 B. C. to the times of Julius Cæsar played havoc with the years, especially in the half century preceding the Julian reformation. It is absolutely impossible to fix any date to a certainty between the founding of Rome and the beginning of the Christian era. The birth of Julius Cæsar is given as Quintilis 10th, 100 B. C. Supposing this right for that particular year, what effect would the vagaries of the pontiffs have, who continually

set aside the regular method of reckoning, putting in or leaving out days and days to accommodate the whims of their politics? This 10th of Quintilis might be 10, 20, or 30 days on either side, could we know exactly the variation made in each year; but of this there is merely a fragment here and there,—no full account.

Still well-meaning men continually settle this confusion, as they think. They write books about it; they bombard the newspapers and the editor of this Journal with their "baseless fabrics." It would be well if all such would read and heed the following extract from Sir John Herschel's Outlines of Astronomy:

"According to the Augustan reform, the years A. U. C. 761, 765, 769, etc., which are now called A. D. 8, 12, 16, etc., are leap years. And starting from *this* as a certain fact, (for the statements of the transaction by classical authors are not so precise as to leave *absolutely no doubt* as to the previous intermediate years), astronomers and chronologists have agreed to reckon backwards in unbroken succession on this principle, and thus to carry the Julian chronology into past time, *as if* it had never suffered such interruption, and *as if* it were certain (which it is not, though we conceive the balance of probabilities to incline that way) that Cæsar, by way of securing the intercalation as a matter of precedent, made his initial year, 45 B. C., a leap year. Whenever, therefore, in the relation of any event, either in ancient history or in modern, previous to the change of style, the time is specified in our modern nomenclature, it is always to be understood as having been identified with the assigned date by threading the mazes (often very tangled and obscure ones) of special and national chronology, and referring the day of its occurrence to its place in the Julian system *so interpreted*."

There you have it. This extract confirms and emphasizes every assertion made in this article on the subject. It is but the concluslon of Ideler, perhaps the ablest author who ever wrote on this subject. The work was published over 70 years ago.

After the death of Cæsar Marc Antony proposed that the month in which Cæsar was born should be called Julius. It was so done. And July being an odd month, had 31 days. On the correction of the error concerning the leap year by Augustus, he considered that he, too, should be honored with the name of a month as was his uncle Julius. And he so ordered. But by the calendar August had 30 days only: and to have a month with only 30 days was to admit his inferiority to the great Cæsar. So he ordered that August should have 31 days. This brought three months in succession with 31 days each: July, August,

September. Whereupon it was further ordered that September and November should be reduced to 30 days, and October and December increased to 31. The writer of the article "Calendar" in the Encyclopedia Britannica, speaking of this transaction, says, "For so frivolous a reason was the regulation of Cæsar abandoned, and a capricious arrangement introduced, which it requires some attention to remember." Then to help in this quandary some one—possibly a mathematical poet—wrote:

"Thirty days hath September," etc.

I have seen several ways of keeping in mind the number of days in the several months, some in words, some in action; but the simplest is the following: Shut the left hand and turn the palm downwards: the roots of the four fingers make four elevated points, and three depressions between the four prominences: place the forefinger of the right hand on the root of the forefinger of the left: call it January: then place the finger in the depression between the roots, call this February; then on the root of the middle finger for March: next depression for April: next prominence for May: last depression for June: root of the little finger for July: back to the root of the forefinger for August, and so on through the 12 months. Each high point marks a month of 31 days: the depressions the others. This is very simple, and one always has the rule on hand for immediate use.

But I have omitted the conclusion of the Augustan *reform*, so-called. By the change above detailed seven months have 31 days, and if the other five should each have 30, the year would have 367 days. To make the required correction, another day at the end of the old year was dropped, leaving February with 29 days in leap years and 28 in the others. Wherefore it is an error to say, as is often done, the "additional day for leap year was added to February as being the shortest." The true explanation is given above. It will be seen in a subsequent article that the people of Europe clung to March as the first month, for many a century, the last to give way being the English, only a little over a century ago.

THE STUDY OF THE VARIABLE STARS.

PAUL S. YENDELL.

I.

FOR POPULAR ASTRONOMY.

Since Tycho and Fabricius, in the last years of the sixteenth century, saw, in the constellation Cetus, the unknown star, "stellam insolitam," for which in March 1609 the latter looked

in vain, the interest in the study of these objects, and the increase in the number of them known to us, have gone on in something like a geometrical ratio to the lapse of time.

For nearly a hundred years, Mira remained the only known example; then were found χ Cygni, β Lyræ, δ Cephei, Algol, and so on. A careful numerical examination of the progress of discovery would be of interest, but does not lie within the scope of this paper. Without going into detail, this progress has been substantially as follows: until the present century, the growth of the list of known variables was accidental and slow; Montanari, indeed, claimed to have discovered more than a hundred; but of all his stars, R Hydræ alone now remains upon the catalogues. The systematic search for asteroids, which was begun in the early part of the present century, began the regular progress of accessions; the observations made by Argelander and his assistants for the Bonn Durchmusterung, and continued later by Schönfeld, were fruitful in the same direction, as were also those made by Gould and his assistants, at Cordoba, for the Uranometria Argentina.

The first catalogue of variable stars worthy of the name appeared in 1844, when Argelander published his list of eighteen stars: in 1866 appeared Schönfeld's First Catalogue, of one hundred and thirty stars* followed in 1874 by his Second Catalogue† in which the number was increased to one hundred and forty three.

From 1874 to 1888, several catalogues were issued by minor authorities, the material of which, however, was not sifted with the same critical care as was exercised by Argelander and Schönfeld, and which therefore fail, as Chandler says, "to represent any exact knowledge." In 1888 Chandler published his First Catalogue,‡ which brings up to the date of publication our knowledge of two hundred and twenty-five variable stars; and the rate of discovery had increased to such a degree that in August 1893 his Second Catalogue,§ of two hundred and sixty stars was brought out: a supplement, in June, 1894, increased this number to two hundred and seventy-nine; a second supplement, the issue of which was made imperative by the accumula-

* *Catalog von veranderlichen Sternen. Jahresbenicht des Mannheimer Vereins für Naturkunde*, No. 32, 1866.

† *Zweiter Catalog von veranderlichen Sternen. Mit Noten.* Same publication, No. 39.

‡ Catalogue of Variable Stars, by S. C. Chandler. *Astronomical Journal*, Nos. 179-180.

§ Second Catalogue of Variable Stars, by S. C. Chandler. *Astronomical Journal*, No. 300.

tion of new matter, bringing the number of variables known at that time to three hundred and forty-four stars, appeared in June 1895; while a third supplementary list, published in the *Astronomical Journal* under date of 1896, March 19, raises the total to three hundred and seventy-eight.

The responsibility and labor of properly arranging such a catalogue are immense, and exceedingly critical care has to be exercised in discriminating as to the admission and rejection of the several cases. The mass of evidence which has accumulated, and which must be thus critically examined, is enormous. The numerical work alone of examining and correcting the elements of each and every one of several hundred stars is enough to appal the ordinary observer, who is apt to think it a labor to reduce his own observations.

Many illustrious names are connected with the history of this branch of astronomy. Tycho, Fabricius, Hevel, Huyghens, Kirch, the elder Herschel, Argelander, Gould, Schönfeld, Schmidt, Chandler, are all names which will pass down to posterity as those of men at whose hands the science has received marked benefits, and to be associated in the same work with whom is in itself an honor.

Up to the time of Argelander, who, having been the first to place the work of observation on an accurate and scientific basis, may properly be called the father of this branch of astronomy, no one, excepting Sir William Herschel, seems to have given any sustained attention to the study of the variable stars.

Argelander himself, in beginning the work, followed the rough and imperfect methods of his predecessors; that is, his observed differences were expressed in words such as, "a little; considerably; much;" etc. In 1840 he adopted the system of Herschel,* who expressed the intervals by arbitrary signs; and it was not until March 1842 that he devised and put in use the method now known by his name, and used by nearly all the observers who pursue this work.

He published a detailed description of this method in his two papers on β Lyræ† and in Schumacher's *Jahrbuch* for 1844. It should be well-known to the readers of POPULAR ASTRONOMY, as it has been described and explained by Mr. John A. Parkhurst in the number for November, 1893.

Argelander's numerous observations of over thirty stars, from 1838 to 1866, with detailed discussions of the elements of

* *Astronomische Nachrichten*, Bd. XVIII, s. 13.
† *De Stella β Lyræ Commentatio. Bonnæ* 1844.

several of them, are to be found in Vol. VII of the Bonn Observations,* where they occupy a space of 207 quarto pages of solid matter.

His work was taken up and continued by his assistant and successor, Eduard Schönfeld, afterward Rector of the University of Bonn, who was until his death in 1891, the world's highest authority on variable stars.

At his death, his mantle fell, by the formal action of the Astronomische Gesellschaft, upon Dr. Seth C. Chandler, who is now ably and energetically carrying forward Schönfeld's work and to whose stimulus and support some of our best observers are deeply indebted. For his numerous and able contributions to the literature of the subject, see the *Astronomische Nachrichten* and the *Astronomical Journal, passim.*

Of the three hundred and seventy-eight stars contained in Chandler's Second Catalogue and supplements, at least two hundred and fifteen are distinctly and certainly periodic. In very many cases, especially among the variables of long period, and the stars of the Algol type, the period is affected by systematic inequalities. These are generally periodic, running, according to Chandler, through cycles of fifty or sixty periods on the average, though sometimes of only twenty or thirty periods, with an amplitude of sometimes as much as one-fifth of the period. Of the two hundred and fifteen stars known to be periodic, sixty-nine have been proved to be affected by such inequalities, and numerical values have been assigned to them in forty-three cases. These values are expressed in the elements in terms of E (which signifies the number of periods elapsed since the principal epoch) and when the inequality is found to be periodic, includes one or more terms depending on the sines of angles whose values are empirically determined, and which are therefore commonly known as empirical or sine-terms; as for instance in the case of 3493 R Leonis, whose elements in the Second Catalogue are:

Max. = 1757, April 21 + $312^{d}.90$ E + 25^{d} sin ($2°.75$ E + $318°$).

As an example of the way in which the sine term affects the computed date of maximum, I give here the process of computing the date of the star's present maximum, which is E = 162.

* *Beobachtungen und Rechnungen uber Veranderliche Sterne. Bonner Beobachtungen, Siebenter Band*, pp. 315-524. *Bonn*, 1896.

The Julian date of the principal epoch is			2362902.00
+ 312^d.90 × 162			50689.80
= Julian date of maximum by simple period			= 2413591.80 = 1896, Feb. 1.80
Sine term.			
2°.75 × 162 =	445.50	log sin + 43°.50	9.8378
+	318.00	log 25^d	1.3979
	+ 763.50		
	− 720.00	log sine term = 1.2357 =	+ 17.20
	+ 43.50		Computed date = Feb. 19.00

In the above case, the expression of the law of the inequality is a simple one, but in numerous other cases, as in Algol, *o* Ceti, R Hydræ, formulas have been used involving several terms, often with opposite signs; and in some of these cases the law still eludes expression, any elements thus far computed failing to satisfy all the observations.

Of the causes of stellar variation, we have as yet almost no certain knowledge; various theories have been advanced, mostly based upon pure speculation, but, as a rule those best acquainted with the phenomena have, so far, seemed to be least inclined to theorize as to their causes.

In only a single case have we any positive knowledge of the actual cause of variation. The light-changes of Algol were early suspected by Goodricke to be due to partial eclipse by an opaque satellite revolving about it; this, though unproved, remained the most plausible explanation of the observed phenomena of the star until 1889, when Vogel and Scheiner, at Zurich, found by refined spectrographic observations that, at the times required by this theory, Algol showed a motion in the line of sight, moving away from the Earth when at quadrature before the minimum, and toward it at the corresponding interval afterward, at a rate closely corresponding with that called for by the hypothesis. From these observations the inference was obvious, that Algol is one of those binaries, of which several are known, whose companions, though bearing a large proportion in mass to their bright neighbors, are invisible to us, presumably only shining by reflected light. In one instance, that of Sirius, the companion has actually been seen, after its presence had been theoretically demonstrated. The only difference between these stars and Algol is that in the latter case the observer's position happens to lie in or close to the plane of the star's orbit of revolution.

Chandler (Astronomical Journal, Vol. XI, pp 113-121) has followed up the intimation thus given, and made a thorough and careful discussion of the data available, demonstrating numeric-

ally that the periodic inequality in the star's variation may be explained on the assumption that, with its dark companion, it revolves about a distant, and, as yet, undetected body, in an orbit about equal in dimensions to that of Uranus. Later (A. J., Vol. XIII, pp 45-46) he extends this reasoning to the cases U Ophiuchi and U Cephei, and, from discrepancies in their observed positions, shows with considerable probability that the conditions of these stars are similar to that of Algol.

Tisserand has advanced a theory, which he considers to be more simple than that of Chandler, and in which he accounts for the periodical irregularity by a revolution of the line of the apsides: this, however, also calls for the assumption of the presence of a third body, while the cases above quoted, reasoning from analogy, favor Chandler's hypothesis.

The cause of Algol's variation being certainly demonstrated, has, by a natural assumption, been supposed to apply to all the variables of this type; of this, however, we have no positive knowledge; and certain peculiarities of the observed light-curves of stars of this type, which are in only one or two cases the symmetrical curves called for by this theory, indicate that while probably depending on the same general causes, the explanation of their light-changes may not be altogether so simple as in the case of Algol.

Dunér has theorized very ably upon Y Cygni and Z Herculis, both of which show double periods of variation: his hypothesis is substantially that these stars are ordinary close binaries, consisting of two stars of nearly equal brightness, revolving, as in the case of Algol, in the plane of the observer.

This general explanation, however, only applies to a very limited class of stars, of which at present the certainly known cases do not exceed twenty; and, except perhaps in the cases of β Lyræ and d Serpentis, cannot be stretched beyond the stars of the type of Algol.

The recent spectroscopic discovery by Bélopolsky that δ Cephei is also a close binary, does not seem to me to affect the above conclusion. The asymmetric and inflected form of this star's light-curve, which is known with great accuracy, thanks to the labors of Schönfeld and others, are not accounted for by it: and this asymmetry is the most characteristic peculiarity of all the light-curves of stars of short period, and, in fact of nearly all that we know.

This lack of symmetry of the observed light-curves appears to dispose of all the explanations of their light-changes which have been based upon supposed notions of rotation or revolution.

Regarding the cause of variations of long period, we seem still to be entirely in the dark: any explanation based on a rotary motion is at once confronted by the exceeding lack of symmetry in their light-curves, their marked irregularities, and the lack of constancy in these curves of different epochs; all of which seem impossible of explanation on any such supposition. Lockyer's hypothesis of clashing meteor-swarms is plastic enough to fit any or all of these cases, but seems too forced and far-fetched to be seriously entertained.

The irregular variables, those whose laws of variation as yet elude research—are quite a numerous class, and range through all magnitudes. Of these we know comparatively little, as they do not attract the observer, but offer him the certainty of a long and tedious work in observing, with very little promise of valuable results: still the constant and systematic observation of this class of objects ought in the long run to reward the labors of any one of sufficient patience and self-abnegation to make a business of following them up, with valuable additions to our knowledge.

DORCHESTER 1896 March 24.

ORMOND STONE.

F. P. MATZ.*

Ormond Stone was born January 11, 1847, at Pekin, Tazewell County, Illinois, and was the oldest son of Rev. E. Stone, a travelling preacher of the Illinois Conference of the Methodist Episcopal Church. His father was of New England origin; his mother, Scotch-Irish.

In those early days, Illinois was on the frontier; and the Methodist preachers had large circuits which they changed every year or two. Among the places in which he lived were Canton, Nauvoo and Carthage. From the last of which places the family moved in 1853 to Cook County, and have remained since then in Northern Illinois.

The boy showed a love for mathematics when a mere child. At the age of seven, while living in the village of Libertyville, he discovered a copy of a new arithmetic, Adams', which those interested had attempted to conceal from him. This he read twice, working all the problems each time, in a space of less than six weeks.

* Professor of Mathematics and Astronomy in Irving College, Mechanicsburg, Pennsylvania.

The next year his father moved to DeKalb Center, where his interest in mathematics was further advanced by an acquaintance with Dr. Matteson, a notice of whom has already appeared in this journal. A few years afterwards his father was stationed in Chicago, where the youth passed through the public schools of the city.

While still in the high school, the Dearborn Observatory was founded in connection with the old University of Chicago, whither Professor Safford was called and remained in charge until the great fire in 1872. Young Stone soon made his acquaintance and almost immediately became his pupil, and thus began his career as an astronomer.

After graduating at the high school, he taught one year at Racine College; after which he returned to Chicago to continue his studies at the University. In 1869, in company with Professor Safford, he went to Des Moines, Iowa, to observe the great eclipse of that year. While there, he made the acquaintance of the astronomers sent from the Washington Observatory; and as a result, the next spring he became an assistant in that institution. He was assigned to the Meridian Circle, on which he was employed for the next five years.

In 1875, he was called to the directorship of the Cincinnati Observatory. Here in connection with his assistants, he employed the 11-inch equatorial of that institution in an extended and practically complete series of measures of the then known southern double stars north of 30° south declination. Here, also, he commenced his work as a trainer of young astronomers, of whom now probably a larger number occupy important astronomical positions than the pupils of any other teacher in America.

In 1882, he was invited to take charge of the new Leander McCormick Observatory of the University of Virginia. This had not then been built. The great 26-inch telescope was finally ready for use in the spring of 1885. This building is memorable as possessing the first large dome made by Warner and Swasey. For the *first* time, also, in this country, electricity was applied to the illumination of the circles and micrometer of the great refractor.

As the southern *double-stars* had been observed at Cincinnati, it was appropriate that he should devote this larger instrument to observations of southern *nebulæ*. As a result, hundreds of new nebulæ were discovered; and in 1893 there was published a catalogue of the micrometric measurements of the positions of

southern nebulæ,—the only extended series of such measurements ever made in this country.

Meanwhile Professor Stone has made a special study of the great nebula of Orion, including a great number of photometric observations of the *condensations* of the Huyghenian region, and of the stars, especially of the *variables*, contained therein.

On the completion of the tenth volume of the *Analyst*, published by the late Dr. Hendricks, of Des Moines, Iowa, when that journal ceased to exist, Professor Stone began the publication of the *Annals of Mathematics*. For a time the editorship was shared with him by his colleague, Professor William M. Thornton; but at the close of the second volume, Professor Stone took entire charge, and the journal has been in his hands ever since.

In this elegantly printed bi-monthly journal, some very select problems are proposed for solution; and the solutions of the problems proposed are published as soon as possible. The *main object* of the publication of the *Annals of Mathematics*, by Professor Stone, is *to encourage mathematical research*.

Professor Stone is a brother of Mr. Melville E. Stone, of Chicago, the well known journalist, the founder of the Chicago *Daily News*, and the general manager of the Associated Press.

Professor Stone has written various papers on mathematical and astronomical subjects, which have appeared from time to time in the *Astronomische Nachrichten*, in *Gould's Astronomical Journal* and in the *Annals of Mathematics*.

Professor Stone is also a member of a number of learned societies. In 1888 he was Chairman of the section of Mathematics and Astronomy of the American Association for the Advancement of Science; and he is at present a member of the Council of the American Mathematical Society. *American Mathematical Monthly*.

THE GRAPHIC CONTRUCTION OF ECLIPSES AND OCCULTATIONS.

V.—Rapid Method.

WM. F. RIGGE, S. J.

For Popular Astronomy.

The reader is probably aware that the one great use to which the observation of isolated occultations can be devoted by the professional as well as by the amateur astronomer, is the accurate determination of longitude, when telegraphic facilities and

coöperation with some other observer are not within his reach. As the star disappears and reappears with a suddenness that is apt to startle an inexperienced observer, the determination of this instant of time may be made with great accuracy. Moreover, all those errors are avoided which are due to the size of the telescope, or the irradiation of the Moon's bright limb, as well as those arising in the measurement of lunar distances or altitudes or transits, so that occultations are the one method of determining the longitude by a private observer.

Whether one has in view the determination of his longitude or only the enjoyment of the novelty and beauty of the phenomenon, he desires a rapid method of predicting occultations. Such the graphic method certainly is when compared with logarithmic computation and moreover the accuracy of both is the same. But notwithstanding its expeditiousness, one is apt to tire even of the graphic method when it comes to constructing an ellipse very much like a former one, or even exactly like it, if the old diagram or the data derived from it have been mislaid. Or again, one who has several times carefully constructed an important occultation only to be bitterly disappointed by the weather, does not feel disposed to take much interest in the matter until the night gives certain promise of a successful issue, and then time may not permit him to construct the diagram. The natural consequence is that our interest in occultations abates, and we end by relegating the whole matter to the professional astronomer. What we want, therefore, is a rapid method, one that we can use, if need be, in the Observatory itself, one that requires little or no logarithmic computation, nothing, in fact, but the Ephemeris, some diagrams, paper, pencil and a few simple drawing tools, in a word, a method that is very expeditious and reasonably accurate.

Such a method of predicting occultations will probably be found contained in the present article. The principle upon which it is based, and in fact the whole method is so simple and withal so elementary, that although the writer has never found it in any popular or technical periodical or text-book, but has devised it for his own convenience and that of his students, he has hesitated to publish it for fear of saying what everybody knew, and has therefore taken the present opportunity to incorporate it in a series of elementary articles on the same subject written for the instruction of students and amateurs and not of professional astronomers. Should the latter however find the method acceptable and time-saving, and should the former be encouraged to

enter upon this branch of astronomy, the author will think himself amply rewarded for his labor.

After explaining briefly the diagrams accompanying this article, which must be constructed in advance, once for all, for each place of observation, we shall take an example as usual and show the practical use of the method.

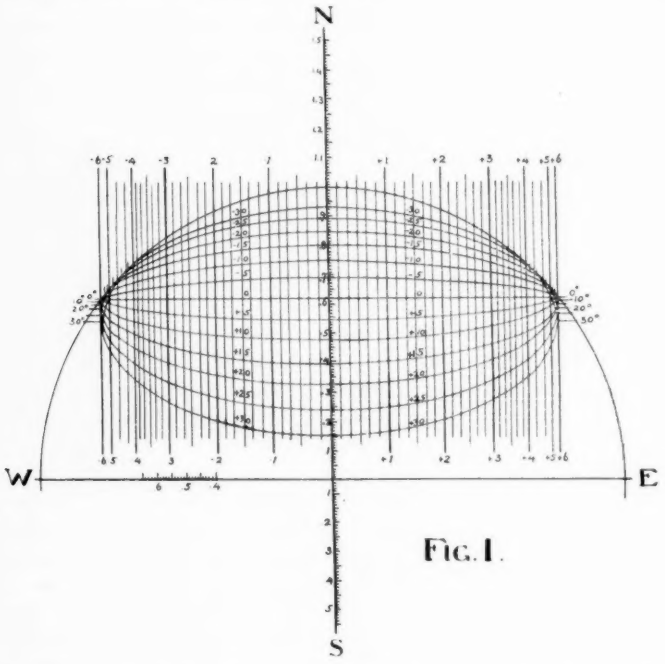


Fig. I.

Explanation of the Diagrams. Fig. I represents the northern half of the Earth's disk with radius unity. On it are drawn all the paths of St. Louis (for which place this diagram has been constructed) for every five degrees of declination from $-30°$ to $+30°$, within which belt all the stars to be occulted are to be found. These paths are the one straight line for the declination $0°$, and six ellipses, all of which have the same semi-major axis, $a = \cos \varphi$. The ellipses are only six and not twelve, because the path for $-25°$, for instance, is the completion of the path for $+25°$, or its nocturnal path, as it might be called. The reader may remember that we called attention to this fact in the second article of this series on solar eclipses (p. 251). The semi-

minor axis $b = \cos \varphi \sin \delta$, is, of course, different for each ellipse, as is $d = \sin \varphi \cos \delta$, the distance between the centre of each ellipse and the centre of the Earth's disk; but b and d are numerically the same for the same positive and negative values of δ. The extremities of the major-axes of all the ellipses except for $\pm 5°$ are indicated to the right and left near the circumference of the large semicircle to facilitate their location in a part of the diagram which is necessarily somewhat crowded. The points of tangency of the ellipses with the circle or edge of the Earth's disk, are also indicated by short lines for all the ellipses except that for $\pm 5°$. Numbers could not be conveniently placed near these points, but it is evident that $\pm 30°$ ought to be farthest from the $0°$ which marks the extremity of the straight line. Starting with this point, we can easily count back to any other. The ordinates of these points of tangency are $\eta = \sin \varphi \sec \delta$.

The use of these ellipses is obvious. If the star to be occulted has the declination $+ 15°$, we use the semi-ellipse marked $+ 15°$. If the declination is $+ 16°$ we imagine an ellipse drawn at one-fifth of the distance from $+ 15°$ to $+ 20°$. This is very easy in practice, and the reader will probably see already that an error of even a whole degree in the declination will have no effect upon the times of the phases when the occultation is central (the Moon's centre passing over the star), or when we are using that part of an ellipse which is near the extremity of the major axis. In the same circumstances an equally large error in the latitude will have as little effect, as it practically shifts the declination ellipse by the amount of the error.

Crossing these ellipses we notice a number of parallel lines placed at unequal distances. The points of intersection of these lines with the ellipses are the positions of St. Louis for nearly every ten minutes, expressed, as we may recall, in stellar hour-angles. The distance of the line $+ 1$ (that is, $+ 1$ hour) from the axis of Y is $\xi = \cos \varphi \sin \tau$, in which τ is equal to 1 hour or 15 degrees. The line $- 1$ is at the same distance to the left. The other hour and ten minute lines were drawn according to the same formula. That these lines are parallel and, may be used for all the ellipses, is evident from the formula itself $\xi = \cos \varphi \sin \tau$, which is independent of δ. The lines $+ 6$ and $- 6$ hours are, of course, tangent to all the ellipses. By means of these hour lines we may easily find the semi-diurnal arc for each star, that is, the hour angle of the star when in the horizon, remembering to continue the numbers beyond 6 hours for plus declinations, because these arcs or times are greater than 6 hours

and to count backwards from the 6^h line, as the line for 7^h is the same as for 5^h.

The axis of Y is graduated to hundredths of the radius from -0.50 to $+1.50$ for conveniently laying-off the values of y' and Y. The axis of X is graduated only between the values 0.40 and 0.65 to the left, because all the values of x' when laid off from the centre lie between these limits. The graduation being executed only to the left will remind us that the value of x' must always be laid off in this direction, as we have explained before in the third article of this series (March of this year) to which we must refer the reader for more detailed explanations.

We might also, for the sake of knowing the star's altitude at a glance, draw circles concentric with the Earth's disk with radii equal to the cosines of every ten degrees. These circles, as well as the ten minute lines, had better be drawn in red ink. We have omitted them, because they would crowd the diagram too much if drawn in black ink.

The diagram we have just explained, that is, Fig. I, need be drawn but once, and only one copy need be used for years, because no lines, pin holes or pencil marks, need ever be made on it.

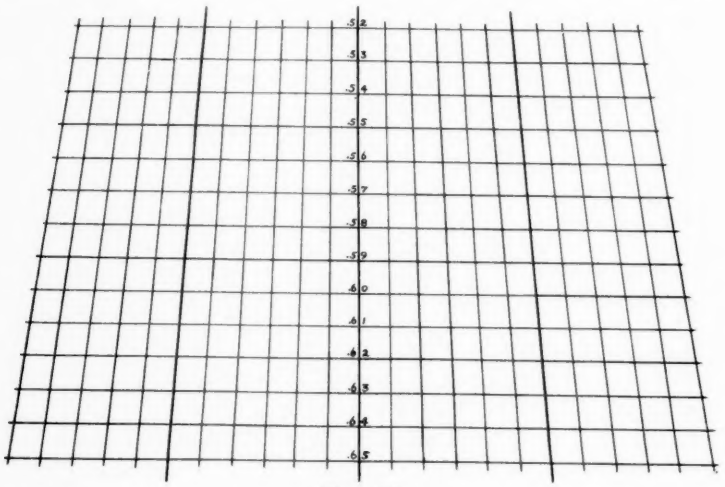


FIG. II.

Fig. II is merely a scale of equal parts for the convenient graduation of the Moon's hourly motion into sixths or 10 minute spaces. It extends from 0.52 to 0.65, these being a short dis-

tance beyond the extreme values of the hourly motion. The exact numerical length of an hour's motion indicated by the heavy lines and marked on the horizontal lines, is not at all necessary; all that is required is that the scale should give equal parts and include all the lengths we may use in practice. It ought to contain about four of each of the various hourly lengths.

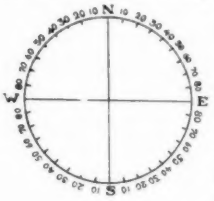


FIG. III.

Fig. III is the Moon's disk struck to the radius 0.272 with its cardinal points and every tenth degree of the circumference marked. It ought to be drawn on gelatine, mica, thin paper or architects tracing cloth, so as to be transparent. Fig. IV will be explained later.

Necessary Outfit. Besides the three diagrams just explained, which, as we have said, need be constructed but once, we shall need some contrivance for drawing parallel lines, such as parallel rulers or a triangular drawing square with a short ruler. No other drawing instruments are required.

Practical Use of the Method. While describing the use of the diagrams, we shall illustrate the directions given by a practical example, choosing for this purpose the occultation of τ Scorpii on August 16, 1896 at St. Louis. As we have seen this same occultation before at greater length in the third article of this series, the reader may refer back to the diagrams there given in case anything in the present article should need further explanation.

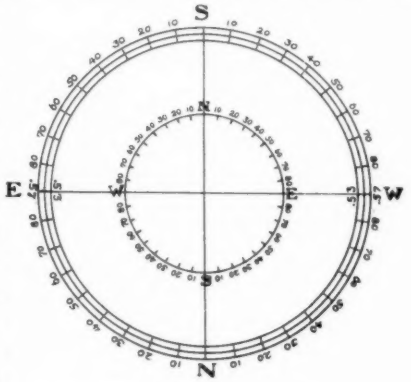


FIG. IV.

1. *The Moon's Hourly Motion.* With the Ephemeris open before us (in our case, the Ephemeris of the current year, 1896, page 437), we lay the straight edge of a piece of paper (such as foolscap) on the diagram so as to cut off the value of x' (that is 0.582) on the axis of X, always to the left from the centre of the disk, and of y' (— 0.076) on the axis of Y, up or down, towards N or S, according as its sign is plus or minus. We then mark on it the length of the hypotenuse, that is, of the line joining the ex-

tremities of x' and y'. This hypotenuse is the Moon's hourly motion in its orbit. The paper edge ought to be long enough to contain about four times the length of this hypotenuse.

2. *The Moon's Path.* While the paper is yet in position, we place one of the parallel rulers against it, and then after taking the paper away, we move the ruler parallel to itself until it cuts the value of Y on the axis of Y. In our case $Y = +1.052$ (Ephem. p. 437). We secure the ruler in this position, by placing for example, a paper weight or a book on it. If parallel rulers are not at hand, their place may be taken by a triangle and ruler. We hold one side, of the triangle against the paper, apply the ruler to another side, and slide the triangle along the ruler until the side which was in contact with the paper cuts the value of Y. The last position of the ruler (or the triangle) is the Moon's path.

3. *The Value of H — λ.* We next compute (mentally) the quantity H — λ, which is to be the reading of the point G, at which the Moon's path crosses the axis of Y. In our case $H = +1^h\,32^m$ (see Ephem.), and $\lambda = +0^h\,53^m$ = the longitude of St. Louis from Washington, and hence $H - \lambda = +0^h\,39^m$.

4. *Graduation of the Moon's Path.* Taking the paper edge to the scale of equal parts, we subdivide the Moon's hourly motion into 10 minute spaces and extend the graduation to four hours. Remembering that this graduation increases algebraically from left to right, that is, from -6^h on the left through -1^h, 0^h, $+1^h$ to $+6^h$ on the right, in the same way as the graduation of the parallel hour lines on Fig. I, we mark the value of $H - \lambda$ (that is, $+0^h\,39^m$ in the present example) at the proper point between two hour marks, and then number the full hours accordingly. If we wish to avoid the necessity of being obliged to return to the scale of proportional parts for further extension of our graduation after the paper scale has been placed in its final position, we should mark the value of $H - \lambda$ in one of the hourly lengths to the right, if it is negative, and in one of those to the left, if it is positive, in an inner hour space for values less than two hours and in an outer one for greater values. In accordance with this practical rule, the value of $H - \lambda$, $+0^h\,39^m$ in the example we have chosen, would be marked in the second hour space, counting from the left, and the numbering of the full hours would be -1^h, 0^h, $+1^h + 2^h + 3^h$.

5. *The Moon's Path Completed.* The paper scale is now to be applied to the ruler (which we have left secured on Fig. I) in such a way that the arrow head or other indication of the value of

$H - \lambda$ ($+ 0^h\ 39^m$) shall fall on the axis of Y. We may find that this position of the scale will cover up the part, if not the whole, of the (St. Louis) ellipse that we have to use, and that the scale has to be used with its edge in the other direction, that is, in other words, that we ought to have graduated the paper scale with the edge downwards instead of upwards, or *vice versa*. A little experience will generally enable us to judge correctly beforehand in which way the scale is to be used, but should the abovementioned contingency arise, we turn the paper edge around, mark anew the value of $H - \lambda$ and renumber the full hours. We then lay a second ruler against the first, and removing the latter, replace it by the paper scale in such a way as to bring the arrow head to the axis of Y. The ruler is now removed, and the paper scale is secured by placing a weight upon it.

6. *The Star's Hour Angles.* With the Moon's path, represented by the paper edge, thus correctly graduated and placed in position, we slide the gelatine or mica circle (Fig. III) with its center on the paper edge, until its center reads the same time on the Moon's path that its circumference, or limb, does on the proper ellipse. As the star's declination, δ, is equal to $- 28° 0'$ in our example, we imagine an ellipse drawn between the $- 25°$ and $- 30°$ ellipses, at two fifths of their distance apart from $- 30°$. Very great accuracy is not necessary, except when the Moon's disk slides along in such a way as to almost graze the star. In the example selected, the equal times will be found to be $+ 0^h\ 25^m$ and $+ 1^h\ 39^m$. These are the star's local hour angles at the instants of immersion and emersion. If no points reading equal times can be found within the range of the radius of the Moon's disk, there is no occultation at the place for which the diagram was constructed. We may, find however, the time and distance at the nearest approach.

7. *The Times of the Phases.* The local mean times of the phases are found by adding (algebraically) the local hour angles $+ 0^h\ 25^m$ and $+ 1^h\ 39^m$ to the local time of transit $6^h\ 46^m$. This last is the same as the Washington time of transit (as was explained before in the third article), and is found by subtracting (algebraically) the Washington hour angle $H + 1^h\ 32^m$, from the Washington time of conjunction $8^h\ 18^m$, given in the Ephemeris (page 437).

8. *Position Angles.* If the gelatine or mica disk (Fig. III) is correctly oriented by means of the many parallel hour lines, mere inspection will give the position angles from the north or south points. To obtain the parallactic angles, we place a ruler on the

centre of the Earth's disk and on either of the points of the ellipse which we have found in No. 6, and then move it parallel to itself until it passes through the centre of the Moon's disk. The vertex is that one of the two points in which it cuts the Moon's limb which is farther from the centre of the Earth's disk. The angle between it and the north point may then be read off and noted down, and added or subtracted, as the case may be, to obtain the angular distance of the star from the vertex. We may then note the Moon's (or rather the star's) altitude by means of the altitude scale explained before. We can get the Moon's age from pages 131, 139 or 417 of the Ephemeris. The time of sunset may be obtained from the equation of time and the Sun's declination (Ephem. p. 128) with the corresponding St. Louis ellipse.

The reader will notice that the only pencil work necessary in the rapid method just described, is the graduation of the paper edge and the writing down of the results. We give here two specimens of the application of the method, which the reader may verify in case he feels so inclined. The first is the occultation of τ Scorpii which we have just described at length. The second is the occultation of 19 Tauri or Taygeta, in the Pleiades. We have noted down the various data in the order in which they are determined in practice. The three data to be obtained from the diagram for each phase, that is, the star's hour angle, its position angle and the position of the vertex, are all found first for the immersion, before the gelatine disk is moved to its second or the emersion position.

OCCULTATIONS FOR ST. LOUIS, MO.

Aug. 16, 1896.			April 5, 1897.	
τ Scorpii	3.2 mag.		19 Tauri	5.0 mag.
Immersion.	Emersion.		Immersion.	Emersion.
$+ 0^h 25^m$	$+ 1^h 39^m$	Hour Angles	$+ 4^h 12^m$	$+ 5^h 16^m$
S 52° E	S 70° W	Position Angles	S 75° E	S 65° W
N 128 E	N 110 W		N 105 E	N 115 W
N 5 E	N 21 E	Position of Vertex	N 57 E	N 55 E
V 123 E	V 131 W	Angle from Vertex	V 48 E	V 170 W
	$6^h 46^m$	Transit		$2^h 41^m$
$7^h 11^m$ P. M.	$8^h 25^m$	Local Mean Time	$6^h 53^m$ P. M.	$7^h 57^m$
7 12	8 26	Standard Time	6 54	7 58
	8 days	Age of Moon		4 days
23°	19½°	Moon's Altitude	35°	22°
	$6^h 52^m$	Sun sets (Local Time)		$6^h 25^m$

Application to Solar Eclipses. The rapid method of predicting occultations, which we have just explained, may also be applied to solar eclipses by using a larger gelatine or mica circle with its radius equal to the radius of the penumbra for that eclipse. Or

we may use one and the same disk for all possible solar eclipses (see Fig. IV), by drawing three concentric circles on it with the radii 0.53, 0.55 and 0.57, the largest and smallest of which approach very closely to the extreme values of the radius of the penumbra, 0.528 and 0.573. Intermediate values of the radius may then be estimated. But the cardinal points on the penumbral circles must be reversed, because in solar eclipses we measure the position angles on the Sun, while in occultations we measure them on the Moon. We may also, in the third place, add a circle of 0.272 radius to the penumbral circles, and then use one and the same gelatine or mica disk for occultation as well as for solar eclipses, (see Fig. IV). This lunar disk will then serve a double purpose, for it will also show us the circle within the penumbra where the magnitude of the eclipse is always 0.5, as we shall see in the next article.

Application to Occultations of Clusters. An occultation of a cluster may be plotted by means of the method here given in a very expeditious manner. We select three stars, one in the middle and one at each end of the cluster. Sometimes two stars, or even one, will be sufficient. We find the elements of the occultations of these stars in the usual way. Then taking a map of the cluster, and drawing a circle on transparent paper to represent the Moon, on the scale of the map, we place this circle correctly oriented in such a way as to have the first star at the proper position angle on the disk at the time of the immersion. We then mark the position of the Moon's centre and note against it the time. We do the same for the emersion. Then we go to the other stars and treat them in a similar way. We will thus have six, four or two positions of the Moon at known times. Connecting these points by straight lines or by an easy curve, and subdividing the spaces between them by means of the scale of equal parts, we have the Moon's apparent path across the map, and may then determine all the occultations very rapidly.

Speed and Accuracy. As to the time required to determine all the elements of an occultation by the above rapid method, the writer's experience shows that after the necessary practice five minutes ought to be sufficient. The times of the phases should be accurate within one minute, that is, as accurate as those obtained by separate plotting in the manner indicated in our third article.

A great deal of time may also be saved in the preliminary investigation of the visibility of an occultation, if we thoroughly familiarize ourselves with the lay of the ellipses in Fig. I. Thus,

for instance, if y is plus, (the Moon going from the left upwards toward the right) and the declination is plus, then Y must be small and H — λ plus to make the occultation sure. A small minus value of H — λ would make it less sure, a large minus value very improbable. A small value of Y would make every occultation impossible for minus declinations, and minus values of Y are generally to be distrusted for even plus declinations. Very often a mere mental picture of the diagram will tell us whether it is worth our while to investigate the occultation at all.

GEORGETOWN COLLEGE OBSERVATORY,
Washington, D. C.

CLIMATE AS RELATED TO ASTRONOMICAL OBSERVATIONS.

WILLIAM H. PICKERING.

FOR POPULAR ASTRONOMY.

In selecting the site for an astronomical Observatory, we should make if possible, in most cases, the climate the fundamental consideration. There are four ways in which the atmosphere may effect our work. They are (*a*) the presence of clouds, (*b*) the transparency of the air, (*c*) the steadiness of the air, (*d*) the presence of dew. In some climates the formation of dew upon the lenses is nearly as serious a hindrance to astronomical work as the presence of clouds. The least interference from our atmosphere in all four of these respects is to be found in a very dry climate. On the other hand, dry climates are in the nature of the case usually far removed from the centres of civilization. It therefore becomes important for us to consider what kinds of astronomical work we shall undertake, and how far they will be effected by the atmospheric conditions. Most astronomical observations may be classified under nine heads as follows:

1. Study of Planetary Detail.
2. Double Star Measures.
3. Meridian Circle and Analogous Work.
4. Photography.
5. Spectroscopy.
6. Solar Work.
7. Comet Seeking.
8. Asteroid Hunting.
9. Photometry.

If the clouds are very thin, or the deposition of dew not very heavy, certain classes of astronomical work may still be carried

on to advantage. Those for which a clear sky are most imporportant are numbers 8, 7 and 9. It is less important for 5, 4 and 1, and of least importance for 2, 3 and 6. In the same way a transparent atmosphere is most important for 7, 4 and 8, less so for 5, 1 and 2, and least so for 9, 3 and 6. A steady atmosphere is most important for 1, 2 and 3, less so for 4, 5 and 6 and least so for 7, 8 and 9.

These results may be tabulated as follows:

Atmosphere.	Important.	Less so.	Least so.
a and *d*	8, 7, 9	5, 4, 1	2, 3, 6
b	7, 4, 8	5, 1, 2	9, 3, 6
c	1, 2, 3	4, 5, 6	7, 8, 9

If one proposes to undertake spectroscopy or solar work, the atmospheric conditions of the Observatory are, comparatively speaking of little consequence. If, on the other hand, one proposes to undertake the study of the finer planetary and lunar detail, little really advanced work can be done except under the very best atmospheric conditions. These are obtained only when the climate is uniform for months at a time. Such conditions occur chiefly in tropical and sub-tropical regions. Rains are particularly detrimental to good seeing. Moderate altitudes of 4,000 to 8,000 feet are desirable, but it is probable that mountain peaks should be avoided. Mountain slopes are certainly bad, and the best conditions will generally be found upon the summit of a low hill rising 200 or 300 feet above the surrounding plain.

HARVARD OBSERVATORY, March 14, 1896.

THE LOWE OBSERVATORY.

LEWIS SWIFT*

FOR POPULAR ASTRONOMY.

It is nearly two years since I removed my astronomical instruments and library from the Warner Observatory, Rochester, N. Y. and about one and a half years since they were mounted in the Lowe Observatory at Echo Mountain, Los Angeles Co., California.

Its elevation above the Pacific Ocean plainly in sight, though 35 miles away, is about 3700 feet. Contrary to general belief I find that this amount of elevation does not conduce to good see-

* Director of Lowe Observatory.

ing to that extent as many suppose. I have had as good seeing in Rochester as here, but only when the wind was northwest. This rarely happened while here ten nights are clear to one there. The principal advantage therefore, this location has over that, is the extraordinary number of clear nights, which curiously enough out-numbers the clear days, exactly the reverse of Rochester weather.

At the request of the weather observer at Sacramento, I commenced on December 14 to keep a record of the number of clear, cloudy and partly cloudy days with the following result:

During the remainder of the month 16 days were clear, and 17 nights.
During January 14 " " " " 20 nights.
During February 21 " " " " 24 nights.

It is the most southern Observatory in the United States. The Tucubaya Observatory, nine miles from Mexico City, is about the only important northern one in the world having so low a latitude.

The latitude of the Lowe Observatory is approximately north 34° 20′ or about 9° south of the Warner Observatory, and 3° south of the Lick.

This difference of 9° imparts a strange appearance to the celestial vault, especially the elevation of the southern constellation, and the depression of the pole star, which seems much out of place.

Every clear night I see the beautiful 1st magnitude star Canopus, some 5° above the horizon. But few people in the United States have ever seen this star. Gamma Crucis, the northernmost star of the Southern Cross, just grazes the horizon when on the meridian, refraction, and my elevation, enabling it to be seen. My low latitude also allows observations of many of Sir John Herschel's and Dunlap's southern nebulæ and I find the descriptions of several incomplete and often erroneous.

That grandest of all visible clusters, Omega Centauri, given by Bayer, is plainly visible at a good elevation. In comparison with this, 13 Messier in Herculis, is a tame affair. It was also discovered by Halley at St. Helena in 1677, and is one of the six discovered by him. It is visible to the naked eye as a faint circular object. As I see it is about 20′ in diameter, and as round as the Sun. In that small space there are many thousand stars from the 13th to the 15th magnitude, suns every one, no doubt doing the same service as our Sun, warming, lighting, guiding and fertilizing a system of planets where people no doubt are

dwelling the same as here. Six nebulous objects only are visible to the naked eye, and are all that were known to the ancients until the invention of the telescope. Since then a harvest by many reapers have increased the number to nearly 10,000. Sir John Herschel's general catalogue of clusters and nebulæ contained 5079 objects, about 1100 being clusters, the remainder, nebulæ. Dreyer's New G. C. contains, including the Index Catalogue, 9416, comprising all known up to December, 1887.

The most conspicuous naked eye cluster is the Pleiades, and is familiar to every one as containing six stars, though some claim to see thirteen. The number visible through the telescope is 671, but a photographic camera, by several hours exposure, reveals on the negative plate 2326.

The grandest cluster in the northern heavens (nebulous through common telescopes) is 13 Messier, about one-third the distance from Eta to Zeta Hercules. It is one of the 6 visible to the unassisted eye. It was also discovered by Halley in 1714. Sir William Herschel has stated that it contains 14000 stars. It has never seemed to me that there are one-half as many and I am inclined to think it is a misprint for 4000. The place of the cluster for 1860 is R. A. $16^h\ 36^m\ 40^s$, Decl. $+\ 36°\ 44'$. The place for the Omega Centauri cluster is (same epoch) $13^h\ 18^m\ 24^s$, Decl. $-\ 46°\ 35'$, and is No. 3531 of the G. C., and 5139 of the N. G. C.

Near some of Sir John Herschel's southern nebulæ I have discovered several overlooked by him, notably, one between G. C. 4863 and 4865, in field with the latter. It is very faint, very small exceedingly elongated to a ray five times as long as broad. I am surprised at his failure to see it. Such exceedingly long thin nebulæ are undoubtedly of the shape of a double convex lens of long focus, with its longer diameter in the direction of the line of sight.

Echo Mountain, Cal., March 1896.

PRACTICAL SUGGESTIONS

THE LUNAR EPHEMERIS.*

J. MORRISON, M. A., M. B., Ph. D.

For Popular Astronomy.

Lunar Distances.

On pages XIII to XVIII inclusive, of each month, are given for every three hours the angular distances of the Moon's centre from the Sun, the planets Venus, Mars, Jupiter and Saturn and certain fixed stars, as seen from the centre of the Earth. These distances are easily computed when we know the R. A. and Decl. of the bodies; thus, if α and δ denote the R. A. and Decl. of the

* Continued from page 369, No. 27.

Moon and α' and δ' those of the Sun, planet or star, we shall have in the spherical triangle formed by the pole and the bodies, the two sides $90 - \delta$ and $90 - \delta'$ and the included angle $\alpha - \alpha'$, to compute the other side which we will denote by D, thus

$$\cos D = \sin \delta \sin \delta' + \cos \delta \cos \delta' \cos (\alpha - \alpha') \qquad (35)$$

which may be computed just as it is by addition and subtraction logarithms, or it may be adapted for computation with ordinary logarithms. "The proportional logarithm" of the difference is simply the log of the time in seconds in which the distance changes by 1"; thus on 1895, Jan. 1, midnight, we see that the change in the angular distance of the Moon from the Sun is in three hours 1° 21′ 32″, then to find the time in which it changes 1″ we have 1° 21′ 32″ : 1″ :: 3^h : x

or $$x = \frac{10800}{4892} = 2^s.207$$

the log of which is 0.3439, the characteristic and decimal point being omitted. By the aid of this we can easily find the time in which the distance changes by any amount, supposing the change to be uniform which, however, is not the case. The most accurate method of finding the time at which the true is equal to the observed distance, is by the interpolation formula taking into account the second differences:—thus let a^t denote any observed distance and a_0 the next least in the computed lunar distances, then b and c being the first and second differences respectively we have

$$a^t = a_0 + tb + \frac{t\,(t-1)}{2}\,c + \ldots\ldots$$

$$= a_0 + tb - \frac{tc}{2} + \frac{t^2}{2} + \ldots\ldots$$

whence $$t = \frac{a^t - a_0}{b - \frac{1}{2}c}, \qquad \left(\text{omitting } \frac{t^2}{2}\right) \qquad (36)$$

which will give the time with all the accuracy required.

Example.—On Jan. 2, 1895 the Moon's apparent angular distance from the Sun as measured with a sextant was found to be 77° W. find the Greenwich mean time. On page 15, American Ephemeris, we see that the time lies between 15 hours and 18 hours and we have

$$a^t - a_0 = 30'\ 27'', \quad b = +4989'', \quad c = +13'',$$

$$t = \frac{1827}{4989 - 6.5} = .3666\ldots\ldots \text{ or } 1^h\ 6^m,$$

therefore the time is $16^h\ 6^m$.

The method of proportional logarithms gives $16^h\ 5^m\ 55^s$.

TABLE I.

MOON'S RETARDATION AND MOTION IN 1 HOUR OF LONGITUDE.

Arg. $\Delta\alpha$ ☽'s hr. motion in R.A.	log. A.	Retardation in 1 hour of Longitude.	Moon's Motion in 1 hour of Longitude.	log $\frac{60^2}{60.164-\Delta\alpha}$
1.74	8.83666	1.618	107.22	1.78971
	7	10	.63	7
1.75	8.83673	1.628	107.85	1.78978
	8	11	.63	8
1.76	8.83681	1.639	108.48	1.78986
	7	11	.64	7
1.77	8.83688	1.650	109.12	1.78993
	8	11	.64	8
1.78	8.83696	1.661	109.76	1.79001
	7	10	.63	7
1.79	8.83703	1.671	110.39	1.79008
	8	10	.64	7
1.80	8.83711	1.681	111.03	1.79015
	7	10	.63	8
1.81	8.83718	1.691	111.66	1.79023
	7	10	.64	7
1.82	8.83725	1.701	112.30	1.79030
	8	11	.64	8
1.83	8.83733	1.712	112.94	1.79038
	7	11	.63	7
1.84	8.83740	1.723	113.57	1.79045
	8	11	.64	8
1.85	8.83748	1.734	114.21	1.79053
	7	10	.64	7
1.86	8.83755	1.744	114.85	1.79060
	8	11	.63	8
1.87	8.83763	1.755	115.48	1.79068
	7	11	.64	7
1.88	8.83770	1.766	116.12	1.79075
	8	10	.64	7
1.89	8.83778	1.776	116.76	1.79082
	7	11	.63	8
1.90	8.83785	1.787	117.39	1.79090
	8	10	.64	7
1.91	8.83793	1.797	118.03	1.79097
	7	11	.64	8
1.92	8.83800	1.808	118.68	1.79105
	7	11	.63	7
1.93	8.83807	1.819	119.31	1.79112
	8	11	.64	8
1.94	8.83815	1.830	1 9.95	1.79120
	7	10	.64	7
1.95	8.83922	1.840	120.59	1.79127
	8	11	.64	8
1.96	8.83830	1.851	121.23	1.79135
	7	10	.64	7
1.97	8.83837	1.861	121.87	1.79142
	7	11	.64	8
1.98	8.83844	1.872	122.51	1.79150
	8	11	.64	7

Arg. $\Delta\alpha$ ☽'s hr. motion in R A	log. A.	Retardation in 1 hour of Longitude.	Moon's Motion in 1 hour of Longitude.	log $\frac{60^2}{60.164 - \Delta\alpha}$
1.99	8.83852	1.883	123.15	1.79157
	7	11	.64	8
2.00	8.83859	1.894	123.79	1.79165
	8	10	.64	7
2.01	8.83867	1.904	124.43	1.79172
	7	10	.64	7
2.02	8.83874	1.915	125.07	1.79179
	8	11	.64	8
2.03	8.83882	1.926	125.71	1.79187
	7	10	.64	7
2.04	8.83889	1.936	126.35	1.79194
	8	11	.64	8
2.05	8.83897	1.947	126.99	1.79202
	7	10	.64	7
2.06	8.83904	1.957	127.63	1.79209
	8	11	.64	8
2.07	8.83912	1.968	128.27	1.79217
	7	11	.65	7
2.08	8.83919	1.979	128.92	1.79224
	8	11	.64	8
2.09	8.83927	1.990	129.56	1.79232
	7	10	.64	7
2.10	8.83984	2.000	130.20	1.79239
	8	11	.64	8
2.11	8 83942	2.011	130.84	1.79247
	7	10	.64	7
2.12	8.83949	2.021	131.48	1.79254
	8	11	.65	8
2.13	8.83957	2.032	132.13	1.79262
	7	11	.64	7
2.14	8.83964	2.043	132.77	1.79269
	8	11	.65	8
2.15	8.83972	2.054	133.42	1.79277
	7	11	.64	7
2.16	8.83979	2.065	134.06	1.79284
	8	11	.64	8
2.17	8.83987	2.076	134.70	1.79292
	7	10	.65	7
2.18	2.83994	2.086	135.35	1.79299
	8	11	.64	8
2.19	8.84002	2.097	135.99	1.79307
	7	10	.64	7
2.20	8.84009	2.107	136.63	1.79314
	8	11	.65	8
2.21	8.84017	2.118	137.28	1.79322
	7	11	.64	7
2.22	8.84024	2.129	137.92	1.79329
	8	11	.65	8
2.23	8.84032	2.140	138.57	1.79337
	7	10	.65	7
2.24	8.84039	2.150	139.22	1.79344
	8	11	.64	8
2.25	0.84047	2.161	139.86	1.79352
	7	11	.65	7
2.26	8.84054	2.172	140.51	1.79359
	8	11	.65	8
2.27	8.84062	2.183	141.16	1.79367
	7	10	.64	7
2.28	8.84069	2.193	141.80	1.79374
	8	11	.65	8

Arg. $\Delta\alpha$ ☽'s hr. motion in R.A.	log A.	Retardation in 1 hr. of Longitude.	Moon's Motion in 1 hour of Longitude.	log $\frac{60^2}{60.164 - \Delta\alpha}$
2.29	8.84077	2.204	142.45	1.79382
	7	11	.64	7
2.30	8.84084	2.215	143.09	1.79389
	8	11	.65	8
2.31	8.84092	2.226	143.74	1.79397
	7	11	.65	7
2.32	8.84099	2.237	144.39	1.79404
	8	10	.65	8
2.33	8.84107	2.247	145.04	1.79412
	7	10	.64	7
2.34	8.84114	2.257	145.68	1.79419
	8	11	.65	8
2.35	8.48122	2.268	146.33	1.79427
	7	11	.65	7
2.36	8.84129	2.279	146.98	1.79434
	8	11	.65	8
2.37	8.84137	2.290	147.63	1.79442
	7	10	.65	7
2.38	8.84144	2.300	148.28	1.79449
	8	11	.65	8
2.39	8.84152	2.311	148.93	1.79457
	7	11	.64	7
2.40	8.84159	2.322	149.57	1.79464
	8	11	.65	8
2.41	8.84167	2.333	150.22	1.79472
	7	10	.65	7
2.42	8.84174	2.343	150.87	1.79479
	8	11	.65	8
2.43	8.84182	2.354	151.52	1.79487
	7	11	.65	7
2.44	8.84189	2.365	152.17	1.79494
	8	11	.65	8
2.45	8.84197	2.376	152.82	1.79502
	7	11	.65	7
2.46	8.84204	2.387	153.47	1.79509
	8	11	.65	8
2.47	8.84212	2.398	154.12	1.79517
	7	11	.65	7
2.48	8.84219	2.409	154.77	1.79524
	8	11	.65	8
2.49	8.84227	2.420	155.42	1.79532
	7	11	.66	8
2.50	8.84234	2.431	156.08	1.79540
	8	11	.65	7
2.51	8.84242	2.442	156.73	1.79547
	8	11	.65	8
2.52	8.84250	2.453	157.38	2.79555
	8	10	.65	7
2.53	8.84258	2.463	158.03	1.79562
	7	11	.65	8
2.54	8.84265	2.474	158.68	1.79570
	8	10	.65	7
2.55	8.84273	2.484	159.33	1.79577
	7	11	.66	8
2.56	8.84280	2.495	159.99	1.79585
	8	11	.65	7
2.57	8.34288	2.506	160.64	1.69592
	7	11	.65	8
2.58	8.84295	2.517	161.29	1.79600
	8	10	.66	7

Arg. $\Delta\alpha$ ☽'s hr. motion in R.A.	log. *A*.	Retardation in 1 hour of Longitude.	Moon's Motion in 1 hour of Longitude.	log $\frac{60^2}{60.164 - \Delta\alpha}$
2.59	8.84303	2.527	161.95	1.79607
	7	11	.65	8
2.60	8.84310	2.538	162.60	1.79615
	8	11	.65	7
2.61	8.84318	2.549	163.25	1.79622
	7	11	.66	8
2.62	8.84325	2.560	163.91	1.79630
	8	11	.66	8
2.63	8.84333	2.571	164.57	1.69638
	7	11	.65	7
2.64	8.84340	2.582	165.22	1.79645
	8	11	.65	8
2.65	8.84348	2.593	165.87	1.79653
	7	11	.66	7
2.66	8.84355	2.604	166.53	1.79660
	8	11	.65	8
2.67	8.84363	2.615	167.18	1.79668
	7	11	.66	7
2.68	8.84370	2.626	167.84	1.79675
	8	11	.65	8
2.69	8.84378	2.637	168.49	1.79683
	7	10	.66	7
2.70	8.84385	2.647	169.15	1.79690
	8	11	.65	8
2.71	8.84393	2.658	169.80	1.79698
	7	11	.66	8
2.72	8.84400	2.669	170.46	1.79706
	8	11	.66	7
2.73	8.84408	2.680	171.12	1.79713
	8	11	.66	8
2.74	8.84416	2.691	171.78	1.79721
	8	10	.65	7
2.75	8.84424	2.701	172.43	1.79728
	7	11	.66	8
2.76	8.84431	2.712	173.09	1.79736
	8	11	.65	7
2.77	8.84439	2.723	173.74	1.79743
	7	11	.66	8
2.78	8.84446	2.734	174.40	1.79751
	8	12	.66	8
2.79	8.84454	2.746	175.06	1.79759
	7	11	.66	7
2.80	8.84461	2.757	175.72	1.79766
	8	11	.66	7
2.81	8.84469	2.768	176.38	1.89774
	8	11	.66	7
2.82	8.84477	2.779	177.04	1.79781
	8	11	.65	8
2.83	8.84485	2.790	177.69	1.79789
	7	10	.66	7
2.84	8.84492	2.800	178.35	1.89796
	8	11	.66	8
2.85	8.84500	2.811	179.01	1.79804
	7	11	.66	7
2.86	8.84507	2.822	179.67	1.79811
	8	11	.66	7
2.87	8.84505	2.833	180.33	1.79818
	7	12	.66	7
2.88	8.84522	2.845	180.99	1.79825

Table II.—For Finding the Illuminated Limb of the Moon.

Argument 1.—The Moon's Declination at the top and bottom of the page.
" 2.—The Apparent Time of Moon's Transit at the left and right hand columns.

Apparent Time of Transit.		∓ 30°	∓ 25°	∓ 20°	∓ 15°	∓ 10°	∓ 5°	∓ 0	Apparent Time of Transit.		☉'s Decl. δ'	
h m	h m	°	°	°	°	°	°	°	h m	h m		°
24 0	0 0	∓ 30.0	∓ 25.0	∓ 20.0	∓ 15.0	∓ 10.0	∓ 5.0	0	12 0	12 0	Jan. 0	− 23.1
23 55	5	30.0	25.0	20.0	15.0	10.0	5.0	0	11 55	5	5	22.6
50	10	30.0	25.0	20.0	15.0	10.0	5.0	0	50	10	10	21.9
45	15	30.0	24.9	19.9	14.9	9.9	5.0	0	45	15	15	21.0
40	20	29.9	24.9	19.9	14.9	9.9	5.0	0	40	20	20	20.0
35	25	29.9	24.9	19.8	14.9	9.9	5.0	0	35	25	25	18.9
30	30	29.8	24.8	19.8	14.8	9.8	5.0	0	30	30	30	17.6
25	35	29.7	24.8	19.7	14.8	9.8	4.9	0	25	35	Feb. 4	16.1
20	40	29.6	24.7	19.7	14.7	9.8	4.9	0	20	40	9	14.5
15	45	29.5	24.6	19.7	14.7	9.8	4.9	0	15	45	14	12.9
10	50	29.4	24.5	19.6	14.6	9.7	4.9	0	10	50	19	11.1
5	55	29.2	24.4	19.5	14.6	9.7	4.8	0	5	55	24	9.3
23 0	1 0	29.1	24.3	19.4	14.5	9.7	4.8	0	11 0	13 0	Mar. 1	7.4
22 55	5	28.9	24.1	19.3	14.4	9.6	4.8	0	10 55	5	6	5.5
50	10	28.8	24.0	19.2	14.3	9.5	4.8	0	50	10	11	3.6
45	15	28.6	23.8	19.1	14.2	9.5	4.7	0	45	15	16 −	1.6
40	20	28.5	23.7	18.9	14.1	9.4	4.7	0	40	20	21 +	0.4
35	25	28.3	23.5	18.7	14.0	9.4	4.7	0	35	25	26	2.4
30	30	28.0	23.3	18.5	13.9	9.3	4.6	0	30	30	31	4.3
25	35	27.8	23.1	18.4	13.8	9.2	4.6	0	25	35	Apr. 5	6.2
20	40	27.6	22.9	18.2	13.6	9.1	4.5	0	20	40	10	8.1
15	45	27.3	22.7	18.0	13.5	9.0	4.5	0	15	45	15	9.9
10	50	27.1	22.4	17.8	13.4	8.9	4.4	0	10	50	20	11.6
5	55	26.8	22.2	17.7	13.2	8.8	4.3	0	5	55	25	13.3
22 0	2 0	26.6	22.0	17.5	13.1	8.7	4.3	0	10 0	14 0	30	14.9
21 55	5	26.3	21.8	17.3	12.9	8.6	4.2	0	9 55	5	May 5	16.4
50	10	25.9	21.5	17.0	12.7	8.5	4.2	0	50	10	10	17.7
45	15	25.6	21.2	16.8	12.6	8.4	4.1	0	45	15	15	19.0
40	20	25.3	20.9	16.6	12.4	8.2	4.1	0	40	20	20	20.1
35	25	25.0	20.6	16.3	12.2	8.1	4.1	0	35	25	25	21.0
30	30	24.6	20.3	16.1	12.0	8.0	4.0	0	30	30	30	21.8
25	35	24.2	20.0	15.8	11.8	7.9	3.9	0	25	35	June 4	22.5
20	40	23.8	19.7	15.6	11.6	7.7	3.8	0	20	40	9	23.0
15	45	23.4	19.3	15.3	11.4	7.5	3.8	0	15	45	14	23.3
10	50	23.0	19.0	15.0	11.2	7.4	3.7	0	10	50	19	23.4
5	55	22.6	18.6	14.7	11.0	7.2	3.6	0	5	55	24	23.4
21 0	3 0	22.2	18.3	14.4	10.7	7.1	3.5	0	9 0	15 0	29	23.2
20 55	5	21.7	17.9	14.1	10.5	6.9	3.5	0	8 55	5	July 4	22.9
50	10	21.2	17.5	13.8	10.3	6.8	3.4	0	50	10	9	22.3
45	15	20.8	17.1	13.5	10.1	6.6	3.3	0	45	15	14	21.6
40	20	20.3	16.7	13.2	9.8	6.5	3.2	0	40	20	19	20.8
35	25	19.8	16.3	12.8	9.5	6.3	3.2	0	35	25	24	19.8
30	30	19.3	15.9	12.5	9.2	6.2	3.1	0	30	30	29	18.7
25	35	18.8	15.5	12.1	9.0	6.0	3.0	0	25	35	Aug. 3	17.4
20	40	18.3	15.0	11.8	8.7	5.8	2.9	0	20	40	8	16.1
15	45	17.7	14.5	11.5	8.4	5.6	2.8	0	15	45	13	14.6
10	50	17.2	14.0	11.1	8.1	5.4	2.7	0	10	50	18	13.0
5	55	16.6	13.6	10.7	7.9	5.2	2.6	0	5	55	23	11.3
20 0	4 0	16.1	13.1	10.3	7.6	5.0	2.5	0	8 0	16 0	28	9.6
19 55	5	15.5	12.6	9.9	7.3	4.8	2.4	0	7 55	5	Sept. 2	7.8
50	10	14.9	12.1	9.5	7.0	4.6	2.3	0	50	10	7	5.9
45	15	14.3	11.7	9.1	6.8	4.5	2.2	0	45	15	12	4.1
40	20	13.7	11.2	8.7	6.5	4.3	2.1	0	40	20	17	2.1
35	25	13.1	10.7	8.3	6.2	4.1	2.0	0	35	25	22	0.2
30	30	12.5	10.2	7.9	5.9	3.8	1.9	0	30	30	27 −	1.8
25	35	11.9	9.7	7.5	5.6	3.6	1.8	0	25	35	Oct. 2	3.7
20	40	11.2	9.1	7.1	5.2	3.4	1.7	0	20	40	7	5.6
15	45	10.5	8.5	6.7	4.9	3.2	1.6	0	15	45	12	7.5
10	50	9.8	8.0	6.3	4.6	3.0	1.5	0	10	50	17	9.4
5	55	9.2	7.4	5.9	4.3	2.8	1.4	0	5	55	22	11.2
19 0	5 0	8.5	6.9	5.4	4.0	2.6	1.3	0	7 0	17 0	27	12.9
18 55	5	7.8	6.4	5.0	3.7	2.4	1.2	0	6 55	5	Nov. 1	14.6
50	10	7.1	7.1	4.5	3.4	2.2	1.1	0	50	10	6	16.1
45	15	6.4	5.8	4.1	3.1	2.0	1.0	0	45	15	11	17.5
40	20	5.7	4.6	3.6	2.7	1.8	0.9	0	40	20	16	18.8
35	25	5.0	4.1	3.2	2.3	1.6	0.8	0	35	25	21	20.0
30	30	4.3	3.5	2.7	2.0	1.4	0.7	0	30	30	26	21.0
25	35	3.6	2.9	2.3	1.6	1.2	0.6	0	25	35	Dec. 1	21.9
20	40	2.9	2.3	1.8	1.3	0.9	0.4	0	20	40	6	22.6
15	45	2.2	1.7	1.3	1.0	0.7	0.3	0	15	45	11	23.0
10	50	1.4	1.1	0.6	0.6	0.4	0.2	0	10	50	16	23.3
5	55	0.7	0.6	0.4	0.3	0.2	0.1	0	5	55	21	23.5
18 0	6 0	∓ 0.0	∓ 0.0	∓ 0.0	∓ 0.0	∓ 0.0	∓ 0.0	0	6 0	18 0	26	23.4
											31 −	23.1
Apparent Time of Transit.		± 30°	± 25°	± 20°	± 15°	± 10°	± 5°	± 0°	Apparent Time of Transit.			

Critera. { This table gives the value of Δ, $\tan \Delta = \cos h \tan \delta$
{ If $\Delta - \delta'$ { = a positive quantity, the south limb is illuminated.
{ = a negative " " north " " "

In using this table, the upper signs are to be taken together and the lower signs together; thus: suppose the arguments are $21^h\ 20^m$ and $-15°$. Entering the table with these we find $\Delta = -11°.6$, again if the arguments are 15^h and $+15°$, we have $\Delta = -10°.7$, and so on.

130. What localities are best adapted to difficult astronomical work? O. L.

Answer:—Our querist is respectfully referred to an article in this number by Professor William H. Pickering who kindly consented to give some of his valuable experience to aid in answering this question and some others kindred to it.

131. What is the best kind of lantern for the projection of ordinary slides for the illustration of celestial objects? M. E.

Answer: We presume our querist is already aware that nothing in the way of a light can take the place of the electric arc or the oxy-hydrogen burner. Walmsley & Fuller, 136 Wabash Ave. Chicago, make an acetylene burner which is probably as good as any made at present. Their "generator No. 3"—the 2 lb. size—is listed at $20; will run four burners or equivalent for 5 hours. We cannot speak of the Welsbach burner, never having tried it. The best light we know anything about is the direct-current arc—the one made by Colt, of New York and Chicago, is superb—quiet as a mouse and absolutely steady—costs $100. As to lenses, everybody uses Darlot's, half or quarter size according to distance from the screen. We have used Darlot lenses for years—they leave little to be desired. Oxyhydrogen cylinders cost from $30 to $50 according to size.

THE PLANETS AND CONSTELLATIONS FOR MAY.

Mercury will be evening planet during the whole of May, coming to greatest eastern elongation, 22° 9′ east from the Sun, May 16. This will be the best time in the year to see Mercury, for the planet will be farther north than the Sun and will set more than an hour after sunset during the entire month, and about two hours after sunset at the middle of the month. Mercury will be in the constellation Taurus, passing 3° south of the Pleiades May 2, 8° north of Aldebaran May 9 and 3° south of β Tauri May 19.

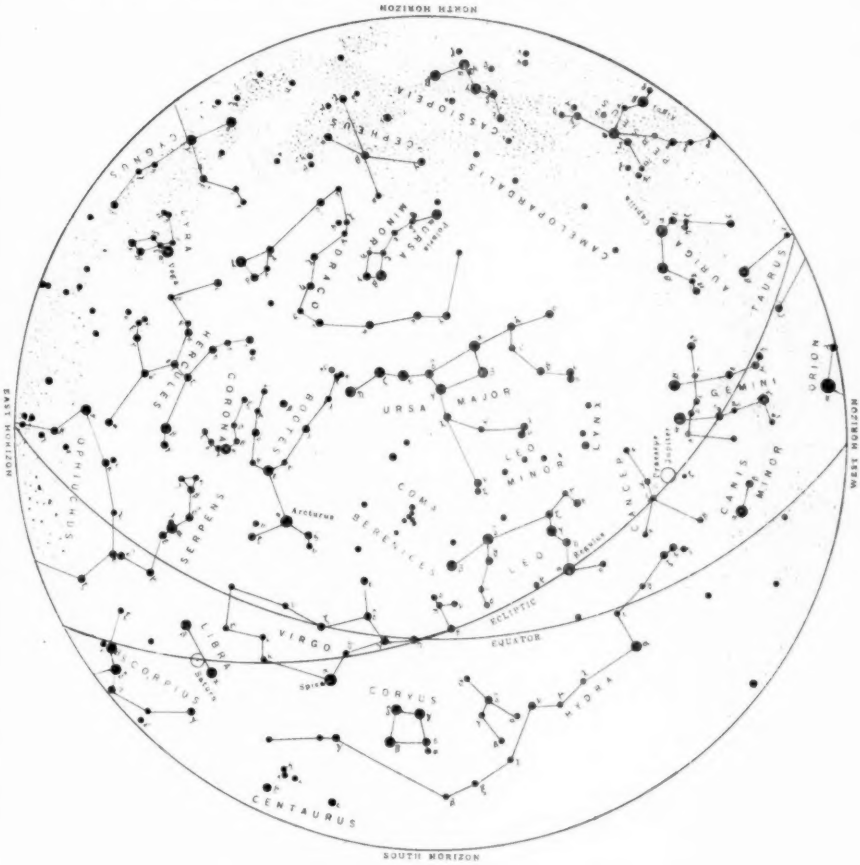
Venus is morning planet but is getting too nearly in line with the Sun to be conspicuous. The phase is nearly full, increasing from 0.95 to 0.98 during the month. On May 3, Venus will be close to the fourth magnitude star o Piscium.

Mars is on the meridian at about eight o'clock in the morning, and may be seen toward the southeast from three to four o'clock. He is among the faint stars south of the great square of Pegasus. Mars is still farther from the Earth than from the Sun, his apparent diameter being only 6″. Mars will be in conjunction with the Moon, 3° 37′ south of the latter at 10^h a. m., May 7.

Jupiter may be observed in the early evening, in the constellation Cancer, and is the most prominent object in the western sky. The reader will do well to try early twilight observations of the planet this month. The Moon will be in conjunction with Jupiter, passing about a degree and a half to the north of the planet, May 18, at $1^h\,18^m$ a. m.

Saturn will be opposite the Sun on May 3, and will be in good position for observation for the next three or four months. The plane of the rings of Saturn is inclined to our line of sight about 21°, so that the details of the ring structure can be plainly seen. Any telescope bearing a magnifying power of 200 ought to show the Cassini division and the inner "crape" ring easily. Among the tables this month we give the times of eastern elongation of the satellites of Saturn, i. e. the times when they attain their greatest distances to the right of the planet, as seen in an inverting telescope. For the slower moving satellites, the times of western elongation and of inferior and superior conjunction, are also given. On

the diagram of the satellite orbits the figure 0 marks the places of eastern elongation. The points 1d, 2d, etc. represent the places of the satellite at intervals of one day, two days, etc. after it has passed 0. The three inner satellites are seen with difficulty except when they are near elongation. The place of Saturn in the constellation Libra is marked upon our map for this month.



THE CONSTELLATIONS AT 9^h P. M. MAY 1, 1896.

Uranus is in the same region of sky with Saturn and so is also in good position for observation. Uranus is not visible to the eye but may easily be found with a small telescope, about 5° south east from Saturn. On May 1 the right ascension of the planet is $15^h\ 22^m$ and the declination south 18° 14′. The motion during the month is 5^m west and 19′ north. The satellites require a powerful telescope to render them visible.

Neptune is not in position to be observed.

Jupiter's Satellites for April.

Central Standard Time.

Phases of the Eclipses of the Satellites for an Inverting Telescope.

I. r

III. d r

II. r

IV. d r

Configuration 8h 30m p. m. for an Inverting Telescope.

Day.	West.	East.
1	○ 1·	○ ·2 ·3 ·4
2		○ ·1 2· ·3 ·4
3	2·1·	○ 3· ·4
4	·2	○ 3· ·1 4·
5	3· ·1	○ ·2 4·
6	·3	○ 2· 1· 4·
7	2· ·3 ·1	○ 4·
8	○ 1· 4·	○ ·3 ·2●
9	4·	○ ·1 2· ·3
10	4· 2· 1·	○ 3·
11	4· ·2	○ 3· ·1
12	·4 3· 1·	○ ·2
13	·4 3·	○ 2·1·
14	·4 ·3 2· ·1	○
15	·4 ·2	○ 1· ·3●
16		○ ·4 2· ·3 ·1●
17	2· 1·	○ ·4 3·
18	·2	○ ·1 3· ·4
19	3· 1·	○ ·2 ·4
20	3·	○ 2· 1· ·4
21	·3 2· ·1	○ 4·
22	·2 ·3	○ 1· 4·
23	·1	○ ·2 ·34·
24	○ 2· ○ 1·	○ 4· 3·
25	·2 4·	○ ·1 3·
26	4· 1· 3·	○ ·2
27	4· 3·	○ ·12.
28	4· ·3 2· ·1	○
29	·4 ·2 ·3	○ 1·
30	·4 ·1	○ ·2 ·3
31	·4	○ 2· 1· 3·

Phenomena of Jupiter's Satellites.

Central Time.

		h	m			
May	1	12	37 P. M.	III	Oc.	Re.
		2	9 "	III	Ec.	Dis.
		3	27 "	II	Oc.	Dis.
		5	42 "	III	Ec.	Re.
		6	37 "	I*	Tr.	In.
		7	52 "	I*	Sh.	In.
		8	50 "	II*	Ec.	Re.
		8	57 "	I*	Tr.	Eg.
		10	12 "	I*	Sh.	Eg.
	2	3	50 "	I	Oc.	Dis.
		7	24 "	I*	Ec.	Re.
	3	10	00 A. M.	II	Tr.	In.
		12	29 P. M.	II	Sh.	In.
		12	55 "	II	Tr.	Eg.
		1	6 "	I	Tr.	In.
		2	20 "	I	Sh.	In.
		3	25 "	II	Sh.	Eg.
		3	26 "	I	Tr.	Eg.
		4	40 "	I	Sh.	Eg.
	4	10	19 A. M.	I	Oc.	Dis.
		1	53 P. M.	I	Ec.	Re.
		11	5 "	III*	Tr.	In.
	5	2	44 A. M.	III	Tr.	Eg.
		4	8 "	III	Sh.	In.
		4	47 "	II	Oc.	Dis.
		7	35 "	I	Tr.	In.
		7	50 "	III	Sh.	Eg.
		8	49 "	I	Sh.	In.
		9	55 "	I	Tr.	Eg.
		10	7 "	II	Ec.	Re.
		11	10 "	I	Sh.	Eg.
	6	4	48 "	I	Oc.	Dis.
		8	21 "	I	Ec.	Re.
		11	21 P. M.	II	Tr.	In.
	7	1	48 A. M.	II	Sh.	In
		2	4 "	I	Tr.	In.
		2	16 "	II	Tr.	Eg.
		3	18 "	I	Sh.	In.
		4	24 "	I	Tr.	Eg.
		4	44 "	II	Sh.	Eg.
		5	38 "	I	Sh.	Eg.
		11	18 P. M.	I	Oc.	Dis.
	8	2	50 A. M.	I	Ec.	Re.
		4	23 "	IV	Tr.	In.
		9	4 "	IV	Tr.	Eg.
		1	5 P. M.	III	Oc.	Dis.
		4	4 "	IV	Sh.	In.
		4	44 "	III	Oc.	Re.
		6	6 "	II	Oc.	Dis.
		6	9 "	III	Ec.	Re.
		8	33 "	I*	Tr.	In.
		8	56 "	IV*	Sh.	Eg.
		9	42 "	III*	Ec.	Re.
		9	47 "	I*	Sh.	In.
		10	53 "	I*	Tr.	Eg.
		11	25 "	II	Ec.	Re.
	9	12	8 A. M.	I	Sh.	Eg.
		5	47 P. M.	I	Oc.	Dis.
		9	19 "	I*	Ec.	Re.
	10	12	43 "	II	Tr.	In.
		3	2 P. M.	I	Tr.	In.
		3	7 "	II	Sh.	In.
		3	38 "	II	Tr.	Eg.
		4	15 "	I	Sh.	In.
		5	22 "	I	Tr.	Eg.
		6	4 "	II	Sh.	Eg.
		6	35 "	I	Sh.	Eg.
	11	10	17 P. M.	I	Oc.	Dis.
		3	48 "	I	Ec.	Re.
	12	3	14 A. M.	III	Tr.	In.
		6	53 "	III	Tr.	Eg.
		7	26 "	II	Oc.	Dis.
		8	7 "	III	Sh.	In.
		9	31 "	I	Tr.	In.
		10	44 "	I	Sh.	In.
		11	50 "	III	Sh.	Eg.
		11	51 "	I	Tr.	Eg.
		12	42 P. M.	II	Ec.	Re.
		1	4 "	I	Sh.	Eg.
	13	6	46 A. M.	I	Oc.	Dis.
		10	17 "	I	Ec.	Re.
	14	2	5 "	II	Tr.	In.
		4	1 "	I	Tr.	In.
		4	26 "	II	Sh.	In.
		5	10 "	II	Tr.	Eg.
		5	13 "	I	Sh.	In.
		6	21 "	I	Tr.	Eg.
		7	22 "	II	Sh.	Eg.
		7	33 "	I	Sh.	Eg.
	15	1	16 A. M.	I	Oc.	Dis.
		4	46 "	I	Ec.	Re.
		5	15 P. M.	III	Oc.	Dis.
		8	46 "	II*	Oc.	Dis.
		8	55 "	III*	Oc.	Re.
		10	8 "	III*	Ec.	Dis.
		10	30 "	I*	Tr.	In.
		11	41 "	I	Sh.	In.
	16	12	50 A. M.	I	Tr.	Eg.
		1	42 "	III	Ec.	Re.
		1	59 "	II	Ec.	Re.
		2	2 "	I	Sh.	Eg.
		2	42 P. M.	IV	Oc.	Dis.
		7	24 "	IV*	Oc.	Re.
		7	45 "	I*	Oc.	Dis.
		11	14 "	I	Ec.	Re.
	17	2	3 A. M.	IV	Ec.	Dis.
		6	48 "	IV	Ec.	Re.
		3	27 P. M.	II	Tr	In.
		5	00 "	I	Tr.	In.
		5	45 "	II	Sh.	In.
		6	10 "	I	Sh.	In.
		6	22 "	II	Tr.	Eg.
		7	20 "	I*	Tr.	Eg.
		8	30 "	I*	Sh.	Eg.
		8	41 "	II*	Sh.	Eg.
	18	2	15 "	I	Oc.	Dis.
		5	43 "	I	Ec.	Re.
	19	7	25 A. M.	III	Tr.	In.
		10	7 "	II	Oc.	Dis.
		11	5 "	III	Tr.	Eg.

19	11	30	A. M.	I	Tr.	In.
	12	7	P. M.	III	Sh.	In.
	12	39	"	I	Sh.	In.
	1	50	"	I	Tr.	Eg.
	3	00	"	I	Sh.	Eg.
	3	17	"	II	Ec.	Re.
	3	49	"	III	Sh.	Eg.
20	8	45	A. M.	I	Oc.	Dis.
	12	12	P. M.	I	Ec.	Re.
21	4	49	A. M.	II	Tr.	In.
	5	59	"	I	Tr.	In.
	7	3	"	II	Sh.	In.
	7	7	"	I	Sh.	In.
	7	44	"	II	Tr.	Eg.
	8	19	"	I	Tr.	Eg.
	9	28	"	I	Sh.	Eg.
	9	59	"	II	Sh.	Eg.
22	3	14	"	I	Oc.	Dis.
	6	41	"	I	Ec.	Re.
	9	29	P. M.	III*	Oc.	Dis.
	11	27	"	II	Oc.	Dis.
23	12	29	A. M.	I	Tr.	In.
	1	9	"	III	Oc.	Re.
	1	36	"	I	Sh.	In.
	2	8	"	III	Ec.	Dis.
	2	49	"	I	Tr.	Eg.
	3	56	"	I	Sh.	Eg.
	4	34	"	II	Ec.	Re.
	5	42	"	III	Ec.	Re.
	9	44	P. M.	I*	Oc.	Dis.
24	1	10	A. M.	I	Ec.	Re.
	6	11	P. M.	II	Tr.	In.
	6	58	"	I*	Tr.	In.
	8	5	"	I*	Sh.	In.
	8	22	"	II*	Sh.	In.
	9	6	"	II*	Tr.	Eg.
	9	18	"	I*	Tr.	Eg.
	10	25	"	I	Sh.	Eg.
	11	18	"	II	Sh.	Eg.
	11	32	"	IV	Tr.	In.
25	4	15	A. M.	IV	Tr.	Eg.
	10	5	A. M.	IV	Sh.	In.
	2	58	P. M.	IV	Sh.	Eg.
	4	14	"	I	Oc.	Dis.
	7	39	"	I*	Ec.	Re.
26	11	40	A. M.	III	Tr.	In.
	12	48	P. M.	II	Oc.	Dis.
	1	28	"	I	Tr.	In.
	2	34	"	I	Sh.	In.
	3	20	"	III	Tr.	Eg.
	3	48	"	I	Tr.	Eg.
	4	6	"	III	Sh.	In.
	4	54	"	I	Sh.	Eg.
	5	51	"	II	Ec.	Re.
	7	49	"	III*	Sh.	Eg.
27	10	44	A. M.	I	Oc.	Dis.
	2	8	P. M.	I	Ec.	Re.
28	7	34	A. M.	II	Tr.	In.
	7	58	"	I	Tr.	In.
	9	3	"	I	Sh.	In.
	9	41	"	II	Sh.	In.
	10	18	"	I	Tr.	Eg.
	10	29	"	II	Tr.	Eg.
	11	23	"	I	Sh.	Eg.
	12	37	P. M.	II	Sh.	Eg
29	5	14	A. M.	I	Oc.	Dis.
	8	36	"	I	Ec.	Re.
30	1	45	"	III	Oc.	Dis.
	2	10	"	II	Oc.	Dis.
	2	28	"	I	Tr.	In.
	3	32	"	I	Sh.	In.
	4	48	"	I	Tr.	Eg.
	5	25	"	III	Oc.	Re.
	5	52	"	I	Sh.	Eg.
	6	8	"	III	Ec.	Dis.
	7	8	"	II	Ec.	Re.
	9	42	"	III	Ec.	Re.
	11	43	P. M.	I	Oc.	Dis.
31	3	5	A. M.	I	Ec.	Re.
	8	57	P. M.	II*	Tr.	In.
	8	57	"	I*	Tr.	In.
	10	00	"	I	Sh.	In.
	10	59	"	II	Sh.	In.
	11	17	"	I	Tr.	Eg.
	11	52	"	II	Tr.	Eg.
32	12	20	A. M.	I	Sh.	Eg.
	1	56	"	II	Sh.	Eg.

Maxima and Minima of Long Period Variables.

MAXIMA.

1896 July.

Date	No.	Star.
1	4315	R Comæ
2	6132	R Ophiuchi
5	5249	V Libræ
6	6682	X Ophiuchi
7	7455	U Capricorni
8	2013	U Aurigæ
8	4940	W Hydræ
8	4596	U Virginis
10	3170	S Hydræ
11	3567	V Leonis
13	7456	RR Cygni

MAXIMA CONT.

1896 July.

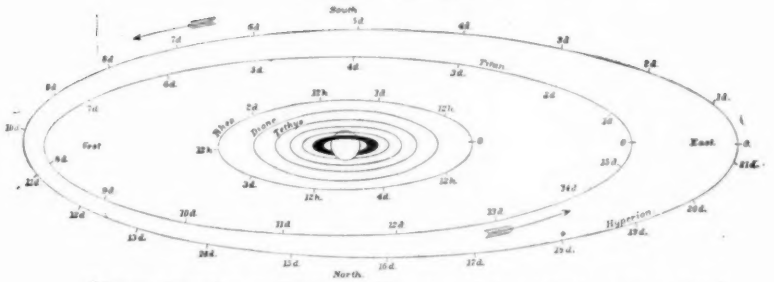
Date	No.	Star.
15	5931	S Ophiuchi
18	7085	RT Cygni
21	2478	R Lyncis
23	2258	V Aurigæ
25	893	U Ceti
26	466	U Piscium
27	5494	S Libræ
27	2445	W Monocerotis
28	5430	T Libræ
30	5194	V Bootis

MINIMA.

1896 July.

Date	No.	Star.
3	3994	S Leonis
7	1222	R Persei
13	806	o Ceti
13	434	S Piscium
23	2080	R Columbæ
24	2539	R Canis min
27	782	R Arietis
27	715	S Arietis
27	7779	S Cephei
30	2946	R Cancri

Saturn's Satellites.



[For explanation see Saturn, in Planets and Constellations, page 474.]

MIMAS.

		h		
May	1	8.0	P. M.	E
	5	3.2	A. M.	W
	6	1.8	"	W
	7	12.4	"	W
	7	11.1	P. M.	W
	8	9.7	"	W
	9	8.3	"	W
	10	6.9	"	W
	14	2.1	A. M.	E
	15	12.7	"	E
	15	11.3	P. M.	E
	16	9.9	"	E
	17	8.6	"	E
	18	7.2	"	E
	22	2.3	A. M.	W
	23	12.9	"	W
	23	11.5	P. M.	W
	24	10.1	"	W
	25	8.8	"	W
	26	7.4	"	W
	30	2.6	A. M.	E
	31	1.2	"	E
	31	11.8	P. M.	E

ENCELADUS.

		h		
May	2	1.8	A. M.	E
	3	10.7	"	E
	4	7.5	P. M.	E
	6	4.4	A. M.	E
	7	1.3	P. M.	E
	8	10.2	"	E
	10	7.1	A. M.	E
	11	4.0	P. M.	E
	13	12.8	A. M.	E
	15	6.5	P. M.	E
	17	3.4	A. M.	E
	18	12.3	P. M.	E

ENCELADUS Cont.

		h		
May	19	9.2	"	E
	21	6.0	A. M.	E
	21	2.9	P. M.	E
	23	11.7	"	E
	25	8.6	A. M.	E
	26	5.5	P. M.	E
	28	2.4	A. M.	E
	29	11.2	"	E
	30	8.1	P. M.	E

TETHYS.

		h		
May	1	2.4	P. M.	E
	3	11.7	A. M.	E
	5	9.0	"	E
	7	6.3	"	E
	9	3.6	"	E
	11	12.9	"	E
	12	10.2	P. M.	E
	14	7.5	"	E
	16	4.8	"	E
	18	2.1	P. M.	E
	20	11.4	A. M.	E
	22	8.7	"	E
	24	6.0	"	E
	26	3.3	"	E
	28	12.6	"	E
	29	9.9	P. M.	E
	31	7.2	"	E

DIONE.

		h		
May	1	3.2	A. M.	E
	2	8.8	P. M.	E
	5	2.5	"	E
	8	8.1	A. M.	E
	11	1.8	"	E
	13	7.5	P. M.	E
	16	1.1	"	E

DIONE Cont.

		h		
May	19	6.8	A. M.	E
	22	12.5	"	E
	24	6.1	P. M.	E
	27	11.8	A. M.	E
	30	5.4	"	E

RHEA.

		h		
May	1	6.3	A. M.	E
	5	6.6	P. M.	E
	10	6.9	A. M.	E
	14	7.2	P. M.	E
	19	7.5	A. M.	E
	23	7.8	P. M.	E
	28	8.1	A. M.	E

TITAN.

		h		
May	2	4.0	P. M.	E
	6	1.4	"	I
	10	5.4	"	W
	14	6.3	"	S
	18	1.4	"	E
	22	10.5	A. M.	I
	26	2.7	P. M.	W
	30	3.7	"	S

HYPERION.

		h		
May	1	9.9	P. M.	S
	7	3.6	"	E
	13	7.3	"	I
	18	2.0	P. M.	W
	23	3.0	A. M.	S
	28	8.6	P. M.	E

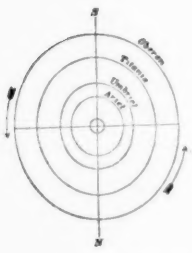
IAPETUS.

		h		
May	4	4.0	A. M.	W
	24	7.8	A. M.	S

Occultations Visible at Washington.

Date 1896.	Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle f'm N pt. °	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
May 18	71 Cancri	8.0	7	7	179	7	49	247	0	42
19	ν Leonis	5.3	5	59	78	6	49	357	0	50
23	75 Virginis	6.0	10	27	173	11	16	254	0	49

The Satellites of Uranus.



ARIEL.

North.		South.	
May 3	8.5 A. M.	May 2	2.3 A. M.
5	9.0 P. M.	4	2.8 P. M.
8	9.5 A. M.	7	3.3 A. M.
10	10.0 P. M.	9	3.8 P. M.
13	10.5 A. M.	12	4.3 A. M.
15	11.0 P. M.	14	4.8 P. M.
18	11.5 A. M.	17	5.3 A. M.
20	12.0 midn.	19	5.8 P. M.
23	12.5 P. M.	22	6.3 A. M.
26	1.0 A. M.	24	6.7 P. M.
28	1.5 P. M.	27	7.2 A. M.
31	2.0 A. M.	29	7.7 P. M.

TITANIA.

North.		South.	
May 7	8.2 A. M.	May 2	11.7 P. M.
16	1.2 "	11	4.7 "
24	6.3 P. M.	20	9.8 A. M.
		29	2.8 "

OBERON.

May 9	10.7 P. M.	May 3	5.0 A. M.
23	10.0 A. M.	16	4.3 P. M.
		30	8.7 A. M.

UMBRIEL.

North.		South.	
May 2	4.0 A. M.	May 4	5.8 A. M.
6	7.5 "	8	9.3 "
10	11.0 "	12	12.7 P. M.
14	2.4 P. M.	16	4.2 "
18	5.9 "	20	7.7 "
22	9.4 "	24	11.2 "
27	12.9 A. M.	29	2.7 A. M.
31	4.4 "		

Ephemeris of Short-Period Variables.

MAY, 1896.

[Greenwich Mean Time].

2279 T MONOCEROTIS.

Max.	Min.
4.37	23 44

2509 ζ GEMINORUM.

6.75	1.73
16.90	11.88
27.06	22 04

4805 W VIRGINIS.

12.69	4.49
29.96	21.76

6368 X SAGITTARII.

7.66	4.78
14.67	11.80
21.68	18.81
28.69	25.82

6404 Y OPHIUCHI.

14.12	7.87
31.24	24.99

6472 W SAGITTARII.

6.94	3.94
14.54	11.54
22.13	19.13
29.73	26.73

6573 Y SAGITTARII.

5.13	3.33
10.90	9.10

6573 Y SAGITTARII CONT.

Max.	Min
16.67	14.87
22.44	21.65
28.22	26.42

6636 U SAGITTARII.

7.44	4.47
14 18	11.21
20 93	17 96
27.67	24 70
	31.45

6758 β LYRÆ.

	5.41
	18.33
	31.25

6924 U AQUILAE.

3.37	1.12
10.40	8.15
17.42	15.17
24.45	22.20
31.48	29.23

7124 η AQUILAE.

7.93	5.56
15.11	12.73
22.29	19 91
29.46	27.09

7149 S SAGITTÆ.

Max.	Min.
5.40	2.00
13.79	10.39
22.17	18.77
30.55	27.15

7437 X CYGNI.

1.41	11.00
17.80	27.39

7483 T VULPECULÆ.

1.83	
6.26	4.96
10.70	9.40
15 14	13.84
19 57	18.27
24.01	22.71
28 44	27.14
	31.58

8073 δ CEPHEI.

3 66	2.07
9 03	7 44
14.39	12.80
19.76	18.17
25.12	23.53
30.49	28.90

Minima of the Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time.]

U CEPHEI.

1896.	
d	h
June 2	16
7	15
12	15
17	14
22	14
27	14

S CANCRI.

June 17	23

δ LIBRÆ

1896.	
d	h
June 22	19
29	19

U OPHIUCHI.

June 1	14
4	22
5	18
6	15
9	23

U OPHIUCHI.

1896.	
d	h
June 10	19
11	13
15	20
16	16
20	21
21	17
25	22
26	18
27	14
30	22

U CORONÆ.

1896.	
d	h
June 5	21
12	18
19	16
26	14

W DELPHINI.

(D. M. 174367.)

June 2	14
7	9
12	5
17	0
21	19
26	15

NOTE.—In *Astronomical Journal* XVI, 72, Dr. Chandler has given to D. M. + 17°.4367, the designation 7399 W Delphini. For W Delphini I have used Pickering's ephemeris in the March *Astrophysical Journal*, the rest are from Hartwig's ephemeris in the *Vierteljahrsschritt*. J. A. PARKHURST.

Marengo, Ill., April 2, 1896.

New Variable Stars.—An examination of the Henry Draper Memorial photographs of stellar spectra by Mrs. Fleming has led to the discovery of fourteen new variable stars of long period, in addition to those previously announced. The spectrum of the fifth star in the following list is of the fourth type. All of the others have spectra of the third type, having also the hydrogen lines bright, and it was this peculiarity which led to their discovery. The variability has been shown by comparison of a large number of photographs, and the variation has been confirmed in each case by the writer. The following table gives the constellation, the catalogue designation of the star, the approximate right ascension and declination for 1900, the number of plates examined, the photographic magnitude, when brightest and faintest as derived from these plates, and the epoch and period as obtained from the material now available. The epoch is expressed in Julian Days omitting the constant 2410000. It is needless to caution astronomers that these elements cannot safely be used to predict future maxima with accuracy. They generally represent the photographic magnitudes during the last eight years, with an average deviation of one or two tenths of a unit. As, however, the periods and light curves in many cases change, the true law can be determined only from long series of observations. The date of the next maximum, as indicated by the formula, is given in the final column.

Constellation	Designation.	R. A. 1900		Decl. 1900		No. Plates	Magn.		Epoch	Period	Maximum.
							Br.	Fr.			
		h	m	°	′						1896.
Sculptor	— 39° 16	0	3.6	— 39	47	43	8.9	< 12.1	165	295	May 25
Columbia	A.G.C. 6135	5	15.6	— 33	48	24	7.6	11.3	134	225	June 23
Canis Minor		7	1.5	+ 9	1	40	10.3	< 13.7	174	364	Sept. 11
Virgo	+ 5° 2708	12	57.6	+ 5	43	51	8.8	9.7			
Apus		14	59.3	— 71	40	58	9.0	< 11.4			
Sagittarius	— 33° 13234	18	21.4	— 33	23	48	8.2	12.3	267	316	July "
Sagittarius	— 19 5347	19	8.1	— 19	2	47	9.7	11.1			
Sagittarius		19	8.7	— 18	59	48	9.9	< 13.3			
Pavo		19	39.5	— 72	1	66	7.6	12.1	156	243	Aug. 29
Microscopium	A.G.C. 28038	0	21.8	— 28	35	49	7.4	8.4			
Pavo		20	47.2	— 63	5	43	9.6	< 12.3			
Grus	— 38° 15044	22	19.9	— 38	4	57	8.6	11.0			
Grus		22	19.9	— 48	57	48	7.2	12.3	90	400	May 10
Aquarius	— 16° 6379	23	47.1	— 16	25	42	8.2	9.3			

The third of these stars is near the border of Monoceros.

-33° 13234 was suspected of variability by Dr. Thome (Annals Cordoba Observatory, Vol. XVII, p. xiii).

A. G. C. 28038 is in Sagittarius according to the Uranometria Nova and Heis.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY. Circular No. 6.
MARCH 10, 1896.

COMET NOTES.

Elements and Ephemeris of Comet *b* 1886 (Swift).—The following were received by telegram April 22. According to the telegram they were computed by Messrs. Buschneer and Searle, which names we take to be mutilations of Leuschner and Seares, since the latter two gentlemen, Professor and student in the University of California, have been very active in calculating the orbits of newly discovered comets. The elements are based upon observations taken April 16, 17 and 19.

ELEMENTS OF COMET *b* 1896.

T = April 17.65 Greenwich mean time.
ω = 1° 45′
ν = 178 16
i = 55 35
q = 0.5663

EPHEMERIS.

	R. A.	Decl.	Brightness.
	h m s	°	
April 23	3 28 0	+ 36 32	1.00
27	3 14 28	+ 46 4	
May 1	2 55 36	+ 53 48	
5	2 32 12	+ 59 40	0.50

The comet has come up from the southern hemisphere, between the Earth and Sun, crossing the ecliptic very near its perihelion point, and is now moving rapidly northwestward and away from the Earth. Its course in the sky lies through the Milky Way in Perseus. By the time this reaches our readers the comet will probably have crossed the northern boundary of Perseus and entered the constellation Cassiopeia. The elements given are hardly accurate enough to trace the path further.

The comet was observed at Northfield April 18, 20, 21 and 23 and was found to be quite bright in spite of moonlight, twilight and low altitude. Its position is getting more favorable all the time, but its brightness will rapidly decrease because of the increasing distance from both the Sun and Earth. In appearance the comet is round, about two minutes of arc in diameter, with a bright central nucleus. A faint short tail is seen with difficulty.

Dr. Swift's New Comet.—From a private letter recently received from Dr. Lewis Swift, Director of Lowe Observatory, Echo Mountain, California, we obtain the following interesting account of his discovery of the latest new comet: This comet was first reported as a suspected discovery by Dr. Swift, on the evening of April 13. It was found a second time by the aid of the 4½-inch comet seeker, and its appearance aroused suspicion that it was the same object that he had seen ten days before, and which he then thought was a nebula. His own words concerning the rediscovery follow:

"The place of the new comet was below the Pleiades, and as far from the group and Aldebaran as the former is from the latter. This configuration would enable me easily to find it the next night which, however, was cloudy.

April 15, in the evening, I had everything about both telescopes in readiness that no time should be lost, and while it was still bright twilight I attempted to find it.

As soon as I had caught it with the small glass, I went at once to the larger one, in which I, at once, saw its cometary character. As twilight became less obtrusive I detected a very faint tail. I saw it for only one or two minutes on the 13th, but was convinced that it was the same object I had vainly watched for motion ten days before, and had pronounced a nebula.

Its motion is very slow having moved but a few degrees in the ten days, and I am undecided about its direction but think it westerly. This evening, after but five or six minutes of observation a cloud hid it as before from my sight.

From circle readings, hastily made, its place is, right ascension, $3^h\ 39^m$; declination north $15°\ 40'$.

Were it not for its early setting, it could, I think, be seen in presence of a half-moon. It is brighter than when first seen ten days ago. LEWIS SWIFT.

GENERAL NOTES.

Dr. See's Astronomical Problem.—Professor T. J. J. See of the astronomical department of the University of Chicago, is reported to be at work on the problem of evolution, not simply that of the Earth, but that of stars and universes. His leading line of thought on the subject is directed to the effects of tidal action in a gradual alteration of the orbits of bodies, this being consequent to the investigation of changes in the distance of the Moon from the Earth due to tidal action at the surface of one or both. Darwin (a son of the author of "The Origin of Species") has led in this investigation, the results of which are stated in popular form by Sir Robert Ball in his "Story of the Heavens." It is shown that the formation of tides on the Earth causes the effective centers of attraction to be some distance away from the center of the undisturbed spheroid, for which reason the line joining the effective centers of gravity in the two bodies forms a small angle with the line that otherwise would be the one along which the two bodies would tend to fall towards each other, and the movement is correspondingly different from what it would be in the undisturbed orbit. This tidal movement accounts for the widening out of the distance between the Earth and Moon and the lengthening of the lunar month from a few hours to about four weeks, and it is easy to see that the process is far from being ended. Professor See is applying this line of reasoning to some of the double stars, and proposes to extend it to all of them if results seem to justify it. He has computed from observed perturbations the probable existence of a yet unseen star connected with a "binary" in the constellation Ophiuchus, but the fact hardly justifies the assertion that he has "discovered" it. Perhaps the stranger may be seen through the new Yerkes telescope when that instrument is put into active service, and if so the work of the computer will deserve to rank second only to that by which the existence of the planet Neptune was made known about fifty years ago.—*Editorial, Chicago Tribune, March 20.*

The Great German Telescope.—Word is just received from F. S. Archenhold, Director of the Guenwald Observatory, that there is to be an astronomical exhibit in connection with the Industrial Exposition to open on the first of the current month at Berlin and to continue until the middle of October next. European and American Observatories are invited to send astronomical work, photographs and any apparatus of interest to astronomical research for the general exhibit.

"It is expected that a great many astronomers," says the circular of information, "and others interested in science will visit the Berlin Exhibition, and especially the great telescope which is to be erected there. Reason to hope that this will be so may be gathered from the intention of a number of societies of scientific proclivities, among them the *Astronomische Gesellschaft*, to meet in Germany at places not distant from the capital." "As the largest refractor hitherto erected in Germany has only been one of 18 inches aperture," writes Director Archenhold, "I am of opinion that great service would be rendered to astronomical science by the erection of a large telescope, which in its dimensions would be comparable to those which other nations have long since found the means to construct. After many years of continuous endeavor, I have at last, with the assistance of the Executive Committee and other patrons of science, succeeded in accomplishing this design, on the occasion of the Berlin Industrial Exhibition, to be held this summer. During the Exhibition, it is intended that the telescope shall as much as possible be used for scientific purposes, and at the close of the same, exclusively so."

Speaking of the details of this new and large telescope, Mr. Ritchie, of *Boston Commonwealth*, makes the following interesting remarks: The mounting is so arranged as to receive two objectives, of which one is designed for precise visual, the other for great light-gathering photographic observations. For this reason the latter will be a double objective of short focal length (20 to 23 feet) and large aperture (43 inches) which for the present will be exhibited in an unfinished condition, as the means for the purchase and polishing of the enormous lenses, which have been very successfully cast by Dr. Schott, can only be raised during the Exhibition. The other objective, on the contrary, is completed, and has an aperture of 28 inches and a focal length of 68 feet.

The glass for the lenses, one set of which will be even larger than those of the Yerkes telescope of Chicago, has been furnished by Schott and Genossen of Jena, while the shaping of them will be done by Steinheil of Munich. The curious mounting will be constructed by the Berlin Machine Co., while the delicate work, circles and graduations, will be by G. Meissner of Berlin.

The ability of the manufacturers of glass to furnish even larger discs than those in use has been known for quite a while. For many years it was the optician who was obliged to wait until the glass-manufacturer could get his rough lenses cast, which was often only after many attempts, but within four or five years the tables have been turned and the glass men have been waiting for orders guaranteeing to furnish glass of excellent sizes even up to five feet in diameter. The size of aperture of the new telescope is therefore not so surprising as is the novel form of mounting.

The telescope will not be covered with a dome, as is universally the case now, but by a cylindrical protective envelope, the whole resembling in a way an enormous cannon, projecting from the pier which supports it. Instead of the rounded dome, there will be this great cylinder, which will be supported only at its inner end where it rests on the pier. The usual gear whereby the telescope follows the motions of the stars in the sky is secured by devices which move telescope, observer, envelope and all, and one would imagine, without really seeing it in operation, at great disadvantage in many ways. The two telescopes, if there are to be two, must point in the same direction, since both are within the same envelope, while there is question of air currents, which with instruments of such powers as these will be would seemingly interpose serious objections to the novel mounting. The supporting of all the weight at one end, with a size of instrument in which already the weight of the lenses tends to distort their figure and

injure the images which they form, would seem less advantageous than the present method of supporting the telescope near its center. And again, if the telescopes are to be fastened to the cylinder which protects them, the weight here necessary to gain strength for its purposes will bring much material close to the tube, which exposed to atmospheric heat and cold will be slow in radiating this heat or cold, and will consequently injure the performance of the glass. But the test of these matters is in actually trying them, and this is what the Berliners intend to do.

Instruments being made at the Brashear Optical Works.—In response to our request Mr. Brashear has given much useful information concerning astronomical instruments in the process of construction at the Allegheny shops.

Professor F. P. Leavenworth's 10½ inch visual and photographic telescope is made on the same plan as those for the Dudley and the Beirout Observatories. The front lens is of flint glass, and the cell is so arranged that a change in the lenses for either photographic or visual work may be made in three minutes, the centering of the lenses being undisturbed. This is a late and very important improvement in the manufacture of a combination telescope.

The Case School of Applied Science, Cleveland, Ohio, has an 11-inch objective nearly completed by Mr. Brashear. Also one of 10 inches aperatare for the private Observatory of Warner & Swasey, Cleveland, Ohio. The 6½-inch telescope for Trinity College, Hartford, has already been set up. Mr. Brashear is finishing a photographic doublet for Dr. Poor of Johns Hopkins University Observatory, another for the University of Tokio, Japan, and still another, a 6-inch photographic lens of 40-foot focus for Professor Holden to be used in the August Eclipse of the Sun.

The entire equipment of the University of Pennsylvania is all completed except the Collimating lenses. The objective for the equatorial is 18-in. clear aperture. The two meridian objectives 4-in. clear aperture and the broken transit 3-in. clear aperture. The spectroscope is one of our large Standard spectroscopes similar to that made for the 16-in. equatorial at Goodsell Observatory at Northfield, Minn.

Perhaps the most interesting piece of work there is the pair of large photographic doublets made for Dr. Max Wolf, of the University Observatory of Heidelberg, Germany. Dr. Hastings has already furnished the preliminary values for the curves and Dr. Schott has the glass discs under way. There will be four complete double objectives making *two* symmetrical doublets, each to be 40 centimetres diameter (16-in.) and only 180 centimetres (72-in.) focal length. They are to be used for the photographs of nebulæ, comets and asteroids; the advantage in using two telescopes at the same time is evident from their value in "checking" results and thus saving a vast amount of time.

The Meaford Astronomical Society in Canada is affiliated with the Astronomical and Physical Society of Toronto. It was organized in 1893 and now has a list of twenty active members. A pamphlet descriptive of its meetings and work is before us. The endorsement accorded to POPULAR ASTRONOMY in this report is gratifying. The language is: The next step was to subscribe to some good serial, and on 5th of February it was decided to select POPULAR ASTRONOMY for that purpose. "This periodical has afforded so much satisfaction that its advent is eagerly looked forward to, and it is carefully read and preserved."

Easter, Note of Correction.—By accident, in the computation of Easter mentioned in the March No. of this Journal, an error running from 1862 to 1889 was committed. The number of times when Easter falls on March 22, is 10; and on the 24, is 11 times—in the 1750 years. Other numbers were changed by one or two units. but it is hardly worth while or space to make any further correction, except to say that the 22 of March, 1818 was the last date for early Easter—not 1874 as printed. The whole series, however, has been tested by the tables in the *Encyclopedia Brittanica*, also by Hutton's tables, which differ wholly in form from those of the *Brittanica*, and were again tested for the day of the week by the universal calendar printed in this Journal some years ago.

R. W. M.

The New Era at Hand.—Mr. Dimbleby of London, under this title has put forth a pamphlet containing more than thirty large pages in small type. The object is to show that the "world will come to an end" in the spring of 1898. This conclusion is reached by a "sleight of hand" performance with certain numbers which manifest a tendency to amount to the same sum, in whatever order they are taken in the adding. Hitherto this has been considered axiomatic rather than wonderful. His calculations are based more especially on two passages of Scripture, in the parts most open to destructive criticism by the learned of modern times. The first is in the last chapter of Daniel and consists of the words "time, times, and half a time." The other is in the thirteenth chapter of Revelation, and is this, "And his number *is* six hundred three score *and* six"

Mr. D. claims that his calculations are new. If he will examine Miller's made about 1840, or those of Dr. Cumings of London, over thirty years ago, he will find the same two passages doing duty for two other prophecies of like import. According to Miller the world was to be destroyed in April, 1843. The prophecy failed of course, then the Londoner extended the time a few years and failed also. Now another man of the same city treats us to a like feast or spectacle. The whole pamphlet is a jumble of false statements of history, of astronomy, of chronology, and, in fact, of every subject which he mentions directly or indirectly.

It is passing strange that intelligent people will suffer themselves to be so easily deluded. For the unthinking it is the natural result. Long ago Tacitus said, "*omne ignotum pro magnifico est*," "every unknown thing is considered magnificent." Prophets of ancient and of modern times deal in things unknown to themselves or to any one else; "The prophets of Baal four hundred and fifty, and the prophets of the groves four hundred and fifty:"—a goodly number for a small territory. "And Elijah said unto them, take the prophets of Baal: let not one of them escape. And they took them; and Elijah brought them down to the brook Kishon, and slew them there." This seems a summary way of disposing of false prophets: at this distance of time I will not attempt to sit in judgment on the case. False prophets are in better luck now.

Let one but say "Here is Scripture,"—and immediately there is a surrender of judgment on the part of most people, let it be for *faith cure* or any other folly. Rather should the hearer demand a proof, and in case it is not forth-coming let the impostor be properly branded at once. To set forth fully all the absurdities in this pamphlet would require more space than half a dozen such pamphlets. I marked a few places—nearly 100—for adverse criticism, passing by most of them however. Take the followlng as specimens:

1st. On p. 19, the title is, "An explanation of the solar cycle." Here is the

definition: "A solar cycle means the number of years by which the same day of the week comes round again on the same date of the month." Let us see how this works. The years 1857, 1863, 1868, 1874, and 1885 all began on Thursday, and all had precisely the same day for the "date of the month." So here you have the "solar cycle." Bnt the first interval is six years; the next, five; the next, six; the last, eleven. Here is a good variety of solar cycles! But there is more to come. On p. 24 he says, "The solar cycle being 7 years." On p. 26 he says, "24 Biblical solar cycles of 15 years each." All these definitions are wrong and they naturally destroy each othsr. This is a fair specimen of the Astronomy of the "Premier Chronologist to the British Chronological and Astronomical Association."

2d. p. 22. "All dates of the Bible are planetary times of the highest scientific accuracy." One might inquire what is meant by "planetary times." But not to waste space on such inquiry, I will say that there is not a date in all the Bible having any such characteristic. The usual style is, "In the eighteenth year of king Jereboam:"—"Now in the fifteenth year of the reign of Tiberius." What the precise date of the year, or even the year itself, is absolutely unknown:—and so of all the rest.

3rd. "Concerning the 6000 years of the world." All intelligent people know that the world had no such late beginning.

4th. "Jesus Christ . . . was . . . born on the night between Friday and Saturday, Dec. 25-26." In like manner all intelligent people know that Christ's birthday was not December 25. But this London "Chronologist" makes it December 26, for Friday ended at sunset, and Saturday followed immediately. So much for the "chronologist."

5th. He speaks of "A copy of the Scriptures . . . written in the fourth century . . . which is the same as our English Bible." This last clause is wholly false.

6th. He objects to the rendering of a clause in Matthew xxiv: "But of that day and hour knoweth no man." The preceding verse says, "Heaven and earth shall pass away." These clauses taken in connection as they must be, the smallest smattering of Greek will show that the translation it exactly right.

7th. "The transit of the planet Mercury on the 10th of November 1894, was a proof of the accuracy of the first chapter of Genesis." This is outside the pale of criticism. "It was precisely at $3^h\ 55^m\ 40^s$. The longitude and the phase of the transit are not given;—this may be considered a providential omission. "The transits at the ascending node must always occur about fifty days after the equinox." This is not true.

8th. In speaking of the change of style in England he says that parliament ordered "that the following year should begin with the first of January instead of the 21st of March." The 21st of March never was the beginning of the year in England.—But Dimbleby is "Premier Chronologist."

I have mentioned eight things for comment. It would be easy to make it *eight hundred*;—the whole thing is a jumble of errors in history, astronomy, chronology, and philosophy; and I hope I may not be considered as wanting in humanity were I to say that it would have been a good thing for many if this prophet had been in Elijah's keeping and gone with his brethren. The only rational basis which I see for the existence of this pamphlet is contained in a line or two at the bottom of page two. It runs thus: "Orders for 25 cents or any higher sum can be sent through the post office in America."

R. W. MCFARLAND.

New Observatory for the University of Illinois.—At the last session of the Illinois legislature an appropriation was made for the erection and equipment of an Observatory for the State University at Champaign. Professor Ira O. Baker has the enterprise in charge. The designs for the building were made under his direction by the Architectural Department of the University. The contract for the instrumental equipment, consisting of a 12-inch equatorial, a 3-inch combined transit and zenith telescope and a chronograph, has been awarded to Warner & Swasey, the optical parts being made by Brashear.

This makes four State Universities which have established Observatories within the past year, all of which have ordered telescopes from Warner & Swasey, with optical parts by Brashear. The list is as follows: University of Pennsylvania, Philadelphia (18-inch aperture), University of Ohio, Columbus (12-inch aperture), University of Minnesota, Minneapolis (10½-inch aperture), University of Illinois, Champaign (12-inch aperture).

New Way of Photographing the Corona in Daylight.—After some hesitation we published a brief article in our March issue, sent us by D. E. Packer of London, England, on a new photographic discovery, so-called, in which it was claimed that the solar corona could be photographed in daylight and the chief characteristics of it shown by the new method. Since the publication of that article three astronomers in England and America have tried the methods described and they all conclude that Mr. Packer is wholly wrong in his claim. What he calls a corona are probably the diffraction images formed by the minute holes so frequently present in tin foil. From general considerations, it seemed to us that the improbability of the results claimed was very great. But after the experiment has been tried by distinguished astronomers no such results as claimed have been obtained. In one instance, with a large 'pin hole' and thin aluminum which was truly continuous before the sensitive plate and an exposure of an hour and a half, not the very slightest trace of action on the plate came out under prolonged development.

Cruise to Russia, Norway and the Midnight Sun, stopping at Bodo, Norway, August 8th, to witness the total eclipse.

The splendid steamer "Ohio" of the American Line, built by the Cramps, builders of the "St. Louis" and "St. Paul," will sail from New York June 27th, for a 60 days cruise to Southampton, St. Petersburg, Stockholm, Copenhagen, Norway and the Midnight Sun, and north as far as Spitzbergen, returning to Bodo, Norway, which is on the central line of the total eclipse. Astronomers will be landed at Bodo one week in advance of the total eclipse to set up instruments. Lectures enroute by Miss Mary Proctor and leading professors of astronomy. The "Ohio" has carried 1,000 passengers of all classes in the past, but this party will be strictly limited to 200 first class. She will carry no freight, second class or steerage. No such opportunity has ever been furnished to combine pleasure and scientific research. Total cost, including ten days hotel accommodations and railroad expense in St. Petersburg and Moscow, $475.00 and upwards, conditional upon berth. The steamer is already more than half full. Send for full particulars to the

THOMAS FOREIGN TOURIST CO.,
1715 Chestnut St., Philadelphia.

An Old Telescope.—I found on sale a telescope a few days ago of which kind but very few exist, at least in America. It proved to be a Gregorian reflector, 2½ in. speculum of metal and to my surprise in very good condition, having been made in 1746. It is 20 inches long, the screw for adjusting the small mirror is attached outside the main tube and the astronomical eyepiece exhibits objects erect. It has a power of about 30, the seller informed me that it only needed the front glass which would cost about 50 cts. I replied that I could probably get along without an objective but the (sh)optician dissented. I paid his price $1.00 and as I left the three spheres he said he would give 50 cts. for it if it could not be fixed. He need not worry over this at all. O. C. BEHR.